Twenty-Third Annual Report of the Commissioners of the State Reservation at Niagara

Oct. 1, 1903 - Sept. 30, 1906

Administration Building.

TWENTY-THIRD ANNUAL REPORT

OF THE

COMMISSIONERS

OF THE

State Reservation at Niagara

From October 1, 1905, to September 30, 1906

TRANSMITTED TO THE LEGISLATURE JANUARY 29, 1907

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JANUARY 29, 1907.

TWENTY-THIRD ANNUAL REPORT

OF THE

COMMISSIONERS OF THE STATE RESERVATION AT NIAGARA.

NIAGARA FALLS, N. Y., *January* 29, 1907.

To the Honorable JAMES W. WADSWORTH, *Speaker of the Assembly, Albany, N. Y.:*

Sir.— I herewith transmit, for the presentation to the Legislature of the State of New York, the Twenty-third Annual Report of the Commissioners of the State Reservation at Niagara, for the fiscal year ended September 30, 1906.

Yours respectfully,

CHARLES M. DOW,

President.

COMMISSIONERS.

CHARLES M. DOW, *President*, Jamestown, N. Y.

GEORGE RAINES ..... Rochester, N. Y.
THOMAS P. KINGSFORD ..... Oswego, N. Y.
ALEXANDER J. PORTER ..... Niagara Falls, N. Y.
ALVAH K. POTTER ..... Lockport, N. Y.

Secretary and Treasurer,

EDWARD H. PERRY ..... Niagara Falls, N. Y.

Superintendent,

EDWARD H. PERRY ..... Niagara Falls, N. Y.

ILLUSTRATIONS.

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New Stone Arch Bridge. As seen from the Mainland.

REPORT.

To the Legislature of the State of New York:

Pursuant to the provision of the law, the Commissioners of the State Reservation at Niagara tender the following as their

TWENTY-THIRD ANNUAL REPORT.

The paramount question which has received our attention during the past year, and which we desire to press most earnestly upon yours, is what shall be done to protect the Falls of Niagara?

The Commissioners have but little power in the premises beyond that of protest. Together with the Government of Canada you have absolute control of the matter. Alone you can fully preserve the American Fall. You can also urge the Government at Washington to hasten a treaty with Great Britain to obtain a like result. But we urge upon you that the latter would be a slow and uncertain method. Prompt action is required to limit the devastation and to repair the injury as far as possible.

A brief resume of conditions and events will present this danger as it exists.

There are five great corporations and one smaller one that are now taking water from the river, above the Falls, and by different devices carrying it around or under the Cataract in the development of power. Some of them, for want of present demand for power, are drawing but little water. This condition will soon change and unless they are limited all will be drawing to the utmost of their capacity.

From the report of the American members of the International Waterways Commission, made to Congress, dated March 19, 1906, we obtain the following data:

The volume of water flowing into Niagara River from Lake Erie at the mean level of the Lake is measured at 222,400 cubic feet per second.

The Niagara Falls Power Company is permitted by its charter to generate 200,000 horsepower.

The Niagara Falls Hydraulic Power and Manufacturing Company is authorized to enlarge its canal to a width of 100 feet and a depth of fourteen feet.

The Canadian Power Company is authorized to construct works which will develop 110,000 horsepower.

The Ontario Power Company is authorized to construct works which will develop 180,000 horsepower.

The Electrical Development Company is authorized to construct works which will develop 125,000 horsepower.

The Park Electric Railway is authorized to develop about 8,000 horsepower.

The first two companies are on the American side and obtain such rights as they have from the State of New York. The other four are on the Canadian side and obtain such rights as they have from the Canadian Government through the Commissioners of the Queen Victoria Niagara Falls Park.

The American members of the International Waterways Commission reduced the water required to complete these concessions to cubic feet per second as follows:

To the Niagara Falls Hydraulic Power and Mfg. Co...	9,500
To the Niagara Falls Power Company.....	17,200
To the Canadian Niagara Power Company.....	9,500
To the Ontario Power Company.....	12,000
To the Electric Development Company.....	11,200
To the Niagara Falls Park Railway Company.....	1,500
Total cubic feet per second.....	60,900

It follows that if these companies follow out their present schemes they will divert twenty-seven per cent. of the mean volume of water that should go over Niagara Falls. It is idle to say that the diversion of twenty-seven per cent. of any body or stream of water will not be perceptible. And it must be remembered that it is not alone the number of feet fall, but the mighty volume and rush of water that makes the grandeur of the cataract so inspiring, and twenty-seven per cent. will not measure the loss in its sublimity when it has been so robbed of its most impressive feature.

But these six corporations are not the only menace to the Falls. Several others have been chartered by the Legislature of this State, and, although four such charters were repealed last Winter, several remain on the statute book, and claim the right to draw water from the river above the Falls. They are the Niagara, Lockport and Ontario Power Company, chapter 722, Laws of 1894; Niagara Power and Development Company, chapter 707, Laws of 1893; and Niagara County Irrigation Company, chapter 259 of the Laws of 1891.

This threatening danger has attracted world-wide attention, and has provoked a loud voice of protest from all parts of the United States and Canada. President Roosevelt was led to take up the matter with the Secretary of State and the Attorney-General, with reference to what might be done by treaty with Great Britain, and by legislation by Congress. The Burton Bill (so called) was passed by Congress and approved June 29, 1906. Substantially it forbids the diversion of water from Niagara River for power purposes except by the revocable permission of Congress or the Secretary of War, for a period of three years, and requests the President to open negotiations with Great Britain for a treaty covering the matter and limits the diversion on the American side to 15,600 cubic feet per second, with a proviso, however, that further diversion may be thereafter permitted but not to such extent that, taken with the diversion on the Canadian side, it will injure the scenic grandeur of Niagara Falls. It also provides for the transmission of electrical energy from the Canadian to the American side, not to exceed 350,000 horsepower.

Prior to the passage of this act, a hearing was had before the House Committee on Rivers and Harbors on April 12, 1906, and this Commission appeared through its President, Mr. Dow, and urged upon the Committee the necessity and importance of putting restraint upon such diversion. At the divers hearings before the Secretary of War relative to the matter, this Commission has opposed the diversion of water from the river. Revocable permits have, however, been given by the Secretary of War, and further applications are pending.

But this act of Congress is designed only to be temporary and by its terms is limited to an existence for three years. It affords no lasting security.

The Legislature of the State of New York, with the Canadian Government, as we have said, have power to preserve Niagara. They are primarily responsible for this duty. They own and have the right, each on its side, to control the waters of the river and the bed of the stream, subject only to the public rights for navigation purposes and commercial rights connected therewith. The Legislature of this State also has absolute power over the corporations it has created, reserved by the Constitution.

We do not invoke the use of this power arbitrarily, however improvidently charters were granted, but we do urge that the rights under the charters given to corporations which have actually developed power be restrained so far as justice will permit and that the charters of those companies before named, which have not developed power, be at once repealed, excepting in the case of the Niagara, Lockport and Ontario Power Company which is engaged in transmitting electricity, and that its right to divert water from the river be withdrawn.

We desire, further, to suggest that a conference between the State of New York and the Canadian Government might lead to concert of action in the matter.

A treaty between the United States and Great Britain could deal with the question only so far as the river is a navigable stream and an international boundary.

The power of the State of New York on the one side, and of the Canadian Government on the other, is more direct and efficient.

THE INCLINED RAILWAY.

More than a year since, the structure which houses the railway to the lower level at Prospect Park was condemned as unsafe by the State Engineer and Surveyor's deputy. He decided that, with some repairs by way of temporary support, it might be used for another year only, and such repairs were made.

The Superintendent found it necessary to close it during February and part of January last Winter, and will be compelled to close it during the approaching Winter. The Commissioners obtained estimates last year from divers contractors as to the cost of reconstruction and were advised that it could be rebuilt for $25,000. They thereupon asked the Legislature for the appro-

priation of that sum for the purpose and it was made at the last session. The Commissioners having plans and specifications prepared by the State Architect, advertised for bids in the manner provided by law, and mailed notices to different contractors who could undertake such work. The only bid made was informal and beyond the appropriation by several thousand dollars. The work was readvertised with the result that the lowest bid was $35,640 not including wiring for lights and heating, plumbing and grading, and the cost of new machinery and cars, all which will add at least $14,500 to the cost of the building under these circumstances. An urgency appropriation should be made of at least $25,000 for this improvement. The necessity for this will be seen when it is considered that the railway is paying to the State substantially one thousand dollars per month in revenue and must be closed till the improvement is made.

Electric Lighting.

On this subject we repeat what we have said before with greater emphasis, if possible. The Reservation is very inadequately lighted at night because we have heretofore been unable to obtain an appropriation to install the necessary apparatus for distributing the electricity. We have an abundance of the electric current already conducted to the grounds, and ready to be delivered free of charge by the Niagara Falls Power Company. We are paying six hundred dollars per annum for inadequate lighting to a private corporation when, with an outlay of $12,000, for a permanent and lasting improvement, the grounds could be beautifully illuminated. There were more than a million people visiting Niagara the last year and very many of them visit the Reservation at night. Thousands are there only for the evening and our alowance for policing being insufficient to afford entire protection the lighting becomes of highest importance, both as a protection and an aid to the public, for whose pleasure the park was established, in seeing the cataract at night.

A niggardly economy in providing for the care of a park which has no equal for grandeur in the world does not reflect credit upon the Empire State. Common business considerations demand the expenditure of such a sum as a matter of profitable investment.

With no better light than we now have there will be a saving of five per cent. on the investment, a good business enterprise. But the result will in fact be far superior to the present condition.

MAINTENANCE.

Why there should be a continued inadequate provision for the maintenance of this Reservation is not apparent. No State property or institution is so insufficiently provided with funds for this purpose in proportion to actual needs. Only $25,000 per annum has been provided with which to meet the expense of paying Superintendent's salary, employees, maintaining miles of roads and pathways, caring for grass, trees and shrubs on 107 acres of land, lighting, heating, repairs and incidentals that are inevitable, and of this $15,171.40 has been paid back to the State in twelve months ending September 30, 1906, being revenue from concessions on the Reservation with the income from the Railway.

The roads are of dirt of a soft nature and easily worn, having never been permanently improved for want of any appropriation therefor, and the travel upon them with automobiles and carriages is very destructive. No adequate maintenance of the Reservation can be had for less than $40,000 per year, and that sum should be appropriated.

MEMORIAL TO MR. GREEN AND MR. WELCH.

The Commissioners have deemed it appropriate that some enduring recognition should be made of the eminent services of the late Honorables Andrew H. Green and Thomas V. Welch, in connection with the establishment, improvement and subsequent care of the Reservation for many years. To their untiring and efficient labors, more than to any others, the grand success of the enterprise should be credited.

In commemoration of their labors in this behalf the Commissioners, without expense to the State, have placed a modest but enduring bronze tablet in the Administration Building, properly inscribed to their memory.

BIDDLE STAIRWAY.

The walk from the Biddle Stairway to the American Falls has been changed from its former position to a course near the margin

of the river. This is a decided improvement. It makes the approach to the Fall and under the water sheet to the Cave of the Winds easier, improves the view and entirely avoids the danger of falling rocks coming from the impending cliff.

Recession of the Falls.

Through the courtesy of Mr. H. C. Rizer, acting director of the Geological Survey for the United States Government, we are able to give some interesting data and pictures with a map made by that Department which enable one to compare the present with conditions existing nearly seventy years ago.

This map shows the outline of the crest of the Falls as found by surveys made in 1842, 1875, 1886, 1890 and 1905. Some discredit is thrown upon the map of 1842 as to the then outline at Prospect Point, but in the main it is doubtless substantially correct. The most noticeable change is that which occurred between 1875 and 1886, at what may now be called the apex of the Horseshoe Fall where the change indicated is 200 feet recession in eleven years. Since that date the recession has been comparatively small at the apex, but has been considerable to the westward. The retrogression, though far from uniform, would seem to average about five feet per year.

The picture of the Horseshoe Fall, made by Captain Hall in 1827, with the camera lucida should be compared with the photograph made in 1886 to get an idea of the action of the water in producing the recession and its progress.

The pictures and map give some indication that the Horseshoe is returning to its former shape.

We transmit herewith the reports of the Secretary and Treasurer, and of the Superintendent for the year ending September 30, 1906.

Appropriations Required.

For maintenance	$40,000 00
For Inclined Railway	25,000 00
For electric lighting	12,000 00
Total	$77,000 00

ESTIMATED RECEIPTS.

The receipts for the next fiscal year are estimated to be as follows:

Inclined Railway*	$10,000 00
Lessee of the Cave of the Winds	1,500 00
Lessee of steamboat dock	600 00
Reservation carriage service	100 00
Total	$12,200 00

Respectfully submitted,

CHARLES M. DOW,
GEORGE RAINES,
THOMAS P. KINGSFORD,
A. K. POTTER,
Commissioners.

As I differ from certain of the conclusions set forth in the foregoing report and cannot consistently concur in some of its recommendations, my signature and approval are both withheld.

ALEXANDER J. PORTER.

*Dependent entirely upon time consumed in securing funds for, and rebuilding the erminal station, railway and cover for same.

HORSESHOE FALL AS SEEN FROM TERRAPIN POINT.

REPORT OF THE SUPERINTENDENT

OF THE

STATE RESERVATION AT NIAGARA

FOR THE

Fiscal Year Ending September 30, 1906.

REPORT OF THE SUPERINTENDENT.

To the Commissioners of the State Reservation at Niagara:

Gentlemen.— I have the honor to submit the following report of work upon the Reservation for the fiscal year ended September 30, 1906.

Inclined Railway Electric Equipment.

The electric power equipment for the Inclined Railway, which was being installed at the time of my last annual report, was completed in time to permit of the use of electric power for operating the Inclined Railway during the Summer months. As a consequence we had an abundance of power without being compelled to resort to the old water wheel.

Administration Building Lights.

The heavy transmission cables which carry power to the Inclined Railway pass through the basement of the Administration Building. As the specifications for the electric power equipment called for three 20 KW. transformers, while but two were necessary for the Inclined Railway plant, one of the transformers was connected to the cables as they pass through the Administration Building and is now transforming the current for the purpose of lighting that building.

Transformer Room.

A brick partition with a metal lined door has been built around the transformer in the basement of the Administration Building and the heavy transmission cables passing through the luncheon room have been covered with heavy galvanized iron casing.

Examination of the Inclined Railway.

Following instructions received from your honorable body, I engaged the services of a competent mechanical engineer to examine the Inclined Railway and the structure enclosing same.

The result of his examination was a condemnation so sweeping in its scope that it was deemed advisable to close the Railway and Free Stairway pending an examination by State officials. The State Engineer and Surveyor was called upon and Mr. D. D. Waldo of that department made a very careful examination and reported that with certain repairs and re-enforcements the Building and Railway could be safely used but advised "against the use of same beyond the opening of the Winter of 1906–07."

REPAIRS TO INCLINED RAILWAY.

The repairs recommended were made and operating resumed, having been idle from January 23d to April 2d, inclusive.

NEW INCLINED RAILWAY STRUCTURE.

By chapter 686 of the Laws of 1906, the State Legislature appropriated $25,500 to reconstruct the Inclined Railway and construct an underground station in Prospect Park, to replace the old stone structure which now obstructs the view of the Falls from all of that section of the park. The request for this appropriation was based on estimates made by local contractors.

The State Architect was requested to furnish plans and specifications for the proposed improvements. After receipt of the approved plans, proposals for the work were called for, same to be opened September 6, 1906. But one bid was received at that time and as it was far in excess of the funds available, the President and Secretary consulted with a representative of the State Architect with a view of having the plans modified so that the work could be done within the appropriation. The plans were gone over very carefully but no alterations could be recommended. Proposals were again asked for, the date of opening the bids being set for November 16, 1906, advertisements being inserted in eight newspapers and one trade journal and personal letters addressed to twenty-six contracting firms. In addition I made personal calls upon ten contractors in New York city explaining the nature of the work and going into the details. Altogether thirteen sets of plans and specifications were sent out or delivered personally. Many of those written to or interviewed were too busy to under-

SMALL ISLANDS JUST ABOVE THE BRINK OF THE AMERICAN FALL.

take the work, others considered it too small to demand their attention. Only two contractors bid on the work. Their figures were so far in excess of the amount of funds available that it becomes necessary to ask for more funds.

The lowest bid received for the work exclusive of the wiring for lights and the heating, plumbing and grading was $35,640. The State Architect estimates that the wiring and plumbing will cost $3,100. The Otis Elevator Company estimates the cost of new machinery and cars at $11,400 making a total of $50,140. As we have but $25,500 available for this purpose it follows that we will require at least $25,000 more for the purposes mentioned.

Repairs to Bridges.

By chapter 686 of the Laws of 1906, $2,000 was appropriated for repairs to the small bridges upon the Reservation. Practically all of the work for which this fund was appropriated has been completed, except placing the concrete and grout around the foundation stones of the bridges connecting the Three Sister Islands which work can only be done during periods of low water, as the current ordinarily is very strong and the water deep. As the past Summer has been marked by extremely high water owing to upper lake influences, we have been compelled to let this part of the work go in hopes that during the Winter the water will be sufficiently diverted by ice to permit of building the cofferdams economically.

New Sprinkling Wagon.

A new 600-gallon sprinkling wagon has been purchased. This wagon is equipped with eight-inch lap tires and acts as a road-roller of about fifteen inches on either side. The season being locally exceptionally dry necessitated almost continual sprinkling of the roads. Two sprinklers were in use most of the time.

Water Main on Riverway.

As authorized by you, the Niagara Falls Water Works Company has installed a water main on the Riverway on which have been placed four fire hydrants.

PATHS.

All of the paths on Green Island and the mainland, as well as the inclined paths on Goat Island have been given a covering of fine broken stone and stone dust. This material has proved much better than gravel as it packs hard and smooth and does not wash away as readily during heavy rains.

TRAIL TO THE CAVE OF THE WINDS.

Under authority granted at a Board meeting held October 31, 1905, the lessee of the Cave of the Winds has, under my supervision, changed the pathway leading to the Cave of the Winds to a point about half-way down the talus slope. The work was done in a substantial manner and does not deface the scenery. This trail, which is about 375 feet long, will overcome the danger from falling rocks, as any rock falling from the face of the cliff will strike on the old walk at the top of the talus slope and remain there.

CAVE OF THE WINDS.

The Cave of the Winds has been visited by more people during the past season than ever before except possibly Pan-American year. The increased interest shown in this wonderful place is an argument for a more modern and convenient method of descending and ascending the cliff at this point.

PIERS AT PORT DAY.

The Niagara Falls Hydraulic Power and Manufacturing Company have removed all of the piers from State lands at Port Day and also cut down the piers on their own property to about one foot above high water, as directed by you. The outlook from Port Day up the river is very much improved.

MAID OF THE MIST.

The Maid of the Mist Steamboat Company has had but one boat in commission, it apparently being taxed to its full capacity. The same painstaking service which has characterized the management in the past was maintained during the season just closed.

Reservation Carriages.

The Reservation Carriage Service under the control of John C. Level, Incorporated, has been conducted on the usual liberal and satisfactory basis and the service rendered has been excellent. The Company now has seven large electric automobiles and ten carriages in service. The rates of twenty-five cents for automobiles and fifteen cents for carriages are entirely satisfactory to the visiting public. There is very little congestion even in the busiest part of the season.

Roads.

During the past year a great amount of work upon the roads on the Reservation has been necessary owing to the fact that nearly all of them are merely dirt roads which are cut up very badly during the season of heavy travel. These roads were badly constructed even for light vehicular service, their constantly increasing use by heavy automobiles and they running in one direction only makes the road maintenance and care an expensive, serious and perplexing question. If possible, sufficient funds should be procured to rebuild on proper lines the road around Goat Island. That portion of the Riverway between Niagara street and Falls street, also the River Road between the new stone arched bridges and the foot of Falls street have been given a heavy coat of gravel and are now in excellent condition.

New Hand Rail.

A new hand rail consisting of an iron cable supported by heavy galvanized iron pipe posts has been erected on the walk leading to Terrapin Point. During the Winter this walk is extremely slippery owing to the freezing spray from the Horseshoe Fall. We hope the new rail will prove a safeguard.

Number of Visitors.

It is estimated that one million three hundred thousand people visited the Reservation during the year, making it one of the busiest in the history of the Reservation. Almost every day the State lands have been thronged and during the very warm weather many remained all night. There has been little disorder and

practically no pocket-picking or confidence games. Of fatalities there have been less than usual, and taken altogether the year has been a remarkable one. The receipts of the Inclined Railway have been about $3,000 in excess of those of the ordinary year, notwithstanding the fact that from January 23d to April 2d, inclusive, the Railway was entirely closed down.

During the fiscal year five bodies have been recovered from the river below the Falls. Of these, two were suicides and three accidental drownings, two on the Canadian side and one off Grand Island. One person, a demented man from Toronto, Ontario, was rescued near the brink of the American Fall by Police Officer J. H. Batts and Fireman Thomas Conroy who risked their lives in the heroic work.

ARRESTS, COMPLAINTS, ET CETERA.

There have been six arrests made upon the Reservation, five for public intoxication and one for disorderly conduct. Of complaints against hackmen there have been five. Four of the hackmen were afterward excluded from driving upon the Reservation. There has been one case of assault and one case of robbery reported and six complaints have been lodged against employees.

The book of records containing details of the above is herewith submitted.

APPEAL FOR MORE FUNDS.

I feel called upon to appeal for a larger fund for maintenance. With the constantly increasing number of visitors to Niagara and the extra police protection and labor made necessary by this increase, the care of the walks, drives, increased cultivated areas, ponds, waterways and the banks of a very rapid river, the currents of which are constantly changing and eroding the river banks which must be protected at heavy expense, together with higher cost for labor, we find it more expensive each year to properly maintain the lands under our supervision.

FUNDS NEEDED.

I recommend that the State Legislature be requested to furnish the following:

Up-stream from Green Island.

For maintenance	$40,000 00
For completion of Inclined Railway	25,000 00
For lighting system	12,000 00
Total	$77,000 00

Receipts.

The receipts during the fiscal year were as follows:

Inclined Railway, month of October, 1905	$731 70
Inclined Railway, month of November, 1905	143 70
Inclined Railway, month of December, 1905	112 20
Inclined Railway, month of January, 1906	73 45
Inclined Railway, month of April, 1906	157 00
Inclined Railway, month of May, 1906	503 50
Inclined Railway, month of June, 1906	1,134 40
Inclined Railway, month of July, 1906	2,856 95
Inclined Railway, month of August, 1906	4,775 15
Inclined Railway, month of September, 1906	2,483 35
Total Inclined Railway receipts	$12,971 40
Lessee Cave of the Winds	1,500 00
Lessee Maid of the Mist	600 00
Reservation Carriage Service	100 00
Total	$15,171 40

All of which has been paid into the Treasury of the State.

Respectfully submitted,

EDWARD H. PERRY,

Superintendent.

REPORT OF THE TREASURER

of the

STATE RESERVATION AT NIAGARA

for the

Fiscal Year Ending September 30, 1906.

Bridge to Sister Islands.

REPORT OF THE TREASURER

The Commissioners of the State Reservation at Niagara, in account with EDWARD H. PERRY, Treasurer, for the fiscal year begun October 1, 1905, and ended September 30, 1906.

MAINTENANCE RECEIPTS.

1905.		*Chapter* 699, *Laws of* 1905.		
Nov.	3.	Payment by State Comptroller on account.	$2,151 68	
Dec.	6.	Payment by State Comptroller on account.	2,011 89	
	30.	Payment by State Comptroller on account.	1,911 21	
1906.				
Feb.	3.	Payment by State Comptroller on account.	1,872 79	
March	1.	Payment by State Comptroller on account.	1,497 78	
April	2.	Payment by State Comptroller on account.	2,200 67	
	26.	Payment by State Comptroller on account.	246 57	
May	2.	Payment by State Comptroller on account.	1,348 61	
	31.	Payment by State Comptroller on account.	1,835 18	
July	5.	Payment by State Comptroller on account.	2,753 27	
Aug.	3.	Payment by State Comptroller on account.	2,190 65	
Sept.	3.	Payment by State Comptroller on account.	2,531 50	
	29.	Payment by State Comptroller on account.	2,440 03	
				$24,991 83

IMPROVEMENT ACCOUNT.

Power Plant, Inclined Railway.

1905.		*Chapter* 729, *Laws of* 1904.		
Oct.	10.	Payment by State Comptroller on account.	$17 90	
Dec.	6.	Payment by State Comptroller on account.	62 12	
1906.				
Feb.	3.	Payment by State Comptroller on account.	18 18	
March	1.	Payment by State Comptroller on account.	191 75	
April	2.	Payment by State Comptroller on account.	89 39	
	26.	Payment by State Comptroller on account.	2,620 00	
				2,999 34

REPAIRS TO BRIDGES.

1906.		*Chapter* 686, *Laws of* 1906.		
Aug.	3.	Payment by State Comptroller on account.	$239 28	
Sept.	3.	Payment by State Comptroller on account.	289 50	
				528 78

RESERVATION RECEIPTS.

1905.			
	INCLINED RAILWAY.		
Oct. 31.	Receipts for month of October	$731 70	
Nov. 30.	Receipts for month of November	143 70	
Dec. 31.	Receipts for month of December	112 20	
1906.			
Jan. 31.	Receipts for month of January	73 45	
April 30.	Receipts for month of April	157 00	
May 31.	Receipts for month of May	503 50	
June 30.	Receipts for month of June	1,134 40	
July 30.	Receipts for month of July	2,856 95	
Aug. 31.	Receipts for month of August	4,775 15	
Sept. 30.	Receipts for month of September	2,483 35	
			$12,971 40
	RENTALS.		
	Reservation Carriage Service	$100 00	
	Cave of the Winds	1,500 00	
	Maid of the Mist	600 00	
			2,200 00
	Total		$43,691 35

EXPENDITURES.

MAINTENANCE.

Abstract No. CLI.

Date.	Voucher.	Name.	Amount.
1905.			
Nov. 3.	2533.	Niagara Falls Hydraulic Power and Manufacturing Co., wages of employees and supplies	$50 00
Nov. 3.	2534.	Niagara Falls Hydraulic Power and Manufacturing Co., wages of employees and supplies	50 00
	2535.	Buffalo and Niagara Falls Electric Light and Power Co., wages of employees and supplies	16 46
	2536.	Charles K. Baker, wages of employees and supplies	50 83
	2537.	Dobbie Foundry and Machine Co., wages of employees and supplies	36 83
	2538.	Dobbie Foundry and Machine Co., wages of employees and supplies	39 88
	2539.	Elderfield-Hartshorn Hardware Co., wages of employees and supplies	29 30
	2540.	Elderfield-Hartshorn Hardware Co., Administration Building, supplies, wages of employees and supplies	63 10

Date.	Voucher.	Name.		Amount
1905.				
Nov. 3.	2541.	A. J. Walker, Administration Building, employees		$8 30
	2542.	Reade Manufacturing Co., wages of employees and supplies		29 50
	2543.	Wicker Lumber Co., wages of employees and supplies		10 56
	2544.	F. E. Dean Co., wages of employees and supplies		10 50
	2545.	W. S. Humbert, Inc., wages of employees and supplies		5 40
	2546.	W. S. Humbert, Inc., wages of employees and supplies		7 64
	2547.	Coldwell Lawn Mower Co., wages of employees and supplies		11 85
	2548.	Edward H. Perry, general expenses		103 45
	2549.	Pay-roll, October, 1905		1,628 08
Dec. 6.	2550.	Cataract Ice Co., wages of employees and supplies		42 00
	2551.	A. J. Walker, general expenses		8 30
	2552.	Smith Premier Typewriting Co., general expenses		10 65
	2553.	Bell Telephone Co., wages of employees and supplies		23 45
	2554.	Buffalo and Niagara Falls Electric Light and Power Co., wages of employees and supplies		18 18
	2555.	Buffalo and Niagara Falls Electric Light and Power Co., wages of employees and supplies		20 22
	2556.	The Austin Western Co., wages of employees and supplies		13 00
	2557.	Thomas P. Kingsford, general expenses		144 69
	2558.	Niagara Falls Hydraulic Power and Manufacturing Co., wages of employees and supplies		50 00
	2559.	Elderfield-Hartshorn Hardware Co., wages of employees and supplies	$40 04	
		General expenses	2 75	
				42 79
	2560.	Orrin E. Dunlap, wages of employees and supplies		42 00
	2561.	Edward H. Perry, wages employees and supplies	$16 60	
		General expenses	32 14	
				48 74
	2562.	Payroll, November, 1905		1,547 87

Date.	Voucher.	Name.		Amount.	
1905.					
Dec. 30.	2563	Frederick W. Kelsey, wages of employees and supplies		$21 00	
	2564	Welch Bros., wages of employees and supplies ...	$21 38		
		Administration Building employees	10 65		
				32 03	
	2565	Bell Telephone Co., wages of employees and supplies		18 00	
	2566	Bell Telephone Co., wages of employees and supplies		15 95	
	2567	Bell Telephone Co., wages of employees and supplies		72 00	
	2568	Frank W. Stevens, general expenses.		39 90	
	2569	Wicker Lumber Co., wages of employees and supplies		20 18	
	2570	Elderfield-Hartshorn Hardware Co., wages of employees and supplies....	$47 08		
		Administration Building employees	3 46		
				50 54	
	2571	Alex. J. Porter, general expenses..		30 65	
	2572	Niagara Falls Hydraulic Power and Manufacturing Co., wages of employees and supplies		50 00	
	2573	Buffalo and Niagara Falls Electric Light and Power Co., wages of employees and supplies		17 80	
	2574	Edward H. Perry, general expenses.		36 40	
	2575	Pay-roll, December, 1905		1,506 76	
					$6,074 78

Abstract No. CLII.

1906.					.....
Feb. 2.	2576	Buffalo and Niagara Falls Electric Light and Power Co., wages of employees and supplies.....		$20 87	
	2577	Cataract Ice Co., wages of employees and supplies		78 00	
	2578	Bell Telephone Co., wages of employees and supplies		22 98	
	2579	Niagara Falls Hydraulic Power and Manufacturing Co., wages of employees and supplies		50 00	
	2580	A. J. Walker, Administration Building, employes		7 50	

NEAR THE SPRING, ON GOAT ISLAND.

Date 1906.	Voucher.	Name.	Amount.
Feb. 2.	2581.	Edward H. Perry, general expenses.	$85 15
	2582.	Charles M. Dow, general expenses.	145 74
	2583	Thomas P. Kingsford, general expenses	22 96
	2584.	Elderfield-Hartshorn Hardware Co., wages of employees and supplies.	9 21
	2585.	Pay-roll, January, 1906	1,430 38
March 1.	2586.	Elderfield-Hartshorn Hardware Co., wages of employees and supplies.	20 36
	2587.	Buffalo and Niagara Falls Electric Light and Power Co., wages of employees and supplies	20 04
	2588.	Niagara Falls Hydraulic Power and and Manufacturing Co., wages of employees and supplies	50 00
	2589.	Bell Telephone Co., wages of employees and supplies	27 60
	2590.	Edward H. Perry, wages of employees and supplies	60 70
	2591.	Edward H. Perry, general expenses.	64 45
	2592.	Pay-roll, February, 1906	1,254 63
April 2.	2593.	Gazette Publishing Co., wages of employees and supplies	11 00
	2594.	A. J. Walker, Administration Building, employees	7 50
	2595.	Brandow Printing Co., wages of employees and supplies	12 89
	2596.	Howard H. Baker Co., wages of employees and supplies	20 75
	2597.	H. W. Buek, wages of employees and supplies	100 00
	2598.	Buffalo and Niagara Falls Electric Light and Power Co., wages of employees and supplies	21 97
	2599.	D. D. Waldo, wages of employees and supplies	15 33
	2600.	J. P. Callahan Ice Co., wages of employees and supplies	56 21
	2601.	Bell Telephone Co., wages of employees and supplies	28 90
	2602.	Elderfield-Hartshorn Hardware Co., wages of employees and supplies.	28 76
	2603.	Cataract Ice Co., wages of employees and supplies	145 50
	2604.	Rochester Germicide Co., wages of employees and supplies	50 00
	2605.	Niagara Falls Hydraulic Power and Manufacturing Co., wages of employees and supplies	50 00

Date.	Voucher.	Name.	Amount.	
1906.				
April 2.	2606.	Edward H. Perry, general expenses..	$78 35	
	2607.	Dobbie Foundry and Machine Co., wages of employees and supplies..	25 00	
	2608.	Pay-roll, March, 1906	1,548 51	
				$5,571 24

Abstract No. CLIII.

1906.				
April 28.	2609.	Sprague and Walsh, wages of employees and supplies.....	$20 00	
	2610.	Cataract Electric Supply Co., wages of employees and supplies.....	36 00	
	2611.	Niagara Falls Hydraulic Power and Manufacturing Co., wages of employees and supplies.....	50 00	
	2612.	Elderfield-Hartshorn Hardware Co., wages of employees and supplies...	15 22	
	2613.	National Press Intelligence Co., general expenses	20 45	
	2614.	Wicker Lumber Co., wages of employees and supplies.....	9 10	
	2615.	Edward H. Perry, general expenses..	95 80	
May 2.	2616.	Bell Telephone Co., wages of employees and supplies.....	32 35	
	2617.	Pay-roll, April, 1906.....	1,316 26	
31.	2618.	Elderfield-Hartshorn Hardware Co., wages of employees and supplies..	29 88	
	2619.	Niagara Falls Hydraulic Power and Manufacturing Co., wages of employees and supplies.....	50 00	
	2620.	W. S. Humbert, Inc., wages of employees and supplies.....	10 09	
	2621.	Bell Telephone Co., wages of employees and supplies.....	35 20	
	2622.	G. Beaton, wages of employees and supplies	7 05	
	2623.	Edward H. Perry, wages of employees and supplies, general expenses	35 71	
	2624.	A. J. Walker, Administration Building, employees	7 50	
	2625.	Pay-roll, May, 1906.....	1,659 75	
				$3,430 36

Abstract No. CLIV.

1906.				
July 1.	2626.	Edward H. Hall, wages of employees and supplies	$58 17	
	2627.	The Courier Co., wages of employees and supplies	78 08	

Date. 1906.	Voucher.	Name.	Amount.
July	1. 2628.	Dobbie Foundry and Machine Co., wages of employees and supplies..	$115 00
	2629.	Harris & Paul, wages of employees and supplies	5 45
	2630.	Edward H. Perry, wages of employees and supplies, general expenses	66 80
	2631.	Wall Rope Works, wages of employees and supplies.....	233 49
	2632.	John G. Milburn, general expenses..	150 00
	2633.	Niagara Falls Hydraulic Power and Manufacturing Co., wages of employees and supplies.....	50 00
	2634.	Hector M. Slocum, general expenses	28 80
	2635.	A. K. Potter, general expenses....	28 60
	2636.	Wicker Lumber Co., wages of employees and supplies.....	17 74
	2637.	Bell Telephone Co., wages of employees and supplies.....	22 25
	2638.	Cataract Ice Co., wages of employees and supplies	30 00
	2639.	Coldwell Lawn Mower Co., wages of employees and supplies.....	16 42
	2640.	Elderfield-Hartshorn Hardware Co., wages of employees and supplies...	32 65
	2641.	Peter Lammerts, wages of employees and supplies	40 50
	2642.	Pay-roll, June, 1906.....	1,748 26
	2643.	McGarigle Machine Co., wages of employees and supplies.....	31 06
Aug.	3. 2644.	Bell Telephone Co., wages of employees and supplies.....	20 00
	2645.	Bell Telephone Co., wages of employees and supplies.....	72 00
	2646.	J. B. Fellows & Co., wages of employees and supplies.....	15 00
	2647.	Edward H. Perry, general expenses..	40 39
	2648.	J. W. Canavan, wages of employees and supplies	53 17
	2649.	City of Niagara Falls, wages of employees and supplies.....	14 00
	2650.	National Press Intelligence Co., general expenses	41 75
	2651.	Niagara Falls Hydraulic Power and Manufacturing Co., wages of employees and supplies	50 00
	2652.	McGarigle Machine Co., wages of employees and supplies.....	6 44

Date. 1906.	Voucher.	Name.	Amount.
Aug. 3.	2653.	Elderfield-Hartshorn Hardware Co., wages of employees and supplies ..	$30 40
	2654.	A. J. Walker, Administration Building, employees	7 90
	2655.	World's Fair Scrap Book Co., general expenses	5 10
	2656.	Pay-roll, July, 1906.....	1,834 50
Sept. 1.	2657.	Elderfield-Hartshorn Hardware Co., wages of employees and supplies, Administration Building employees	35 95
	2658.	Bell Telephone Co., general expense..	18 10
	2659.	P. C. Flynn & Son, wages of employees and supplies.....	179 15
	2660.	National Press Intelligence Co., general expense	7 70
	2661.	Edward H. Perry, general expense, wages of employees and supplies..	36 67
	2662.	William Young, general expense, wages of employees and supplies..	31 94
	2663.	Pay-roll, August, 1906.....	2,141 01
	2664.	Niagara Falls Hydraulic Power and Manufacturing Co., wages of employees and supplies.....	50 00
	2665.	Cataract Electric Supply Co., general expense	30 98
29.	2666.	Niagara Falls Hydraulic Power and Manufacturing Co., wages of employees and supplies.....	50 00
	2667.	Elderfield-Hartshorn Hardware Co., wages of employes and supplies, general expense	28 42
	2668.	Wicker Lumber Co., wages of employees and supplies.....	18 50
	2669.	Dobbie Foundry and Machine Co., wages of employees and supplies..	9 85
	2670.	Mrs. L. W. Pettebone, wages of employees and supplies.....	74 88
	2671.	Miss E. J. Townsend, wages of employees and supplies.....	73 71
	2672.	Estate of Jane H. Wheeler, wages of employees and supplies.....	51 48
	2673.	Bell Telephone Co., general expense..	16 00
	2674.	Edward H. Perry, general expense..	61 56
	2675.	A. J. Walker, general expense....	8 30
	2676.	Welch Bros., general expense.....	97 50
	2677.	Pay-roll, September, 1906.....	1,898 25

Date.	Voucher.	Name.	Amount.	
1906.				
Sept.	29. 2678.	F. W. Oliver Co, wages of employees and supplies	$4 13	
	2679.	F. E. Dean & Co., wages of employees and supplies	7 40	
	2680.	F. E. Dean & Co., wages of employees and supplies	40 05	
				$9,915 45

PAYMENTS FROM SPECIAL APPROPRIATIONS.

CHAPTER 729, LAWS OF 1904.

Abstract No. 1.

Date.	Voucher.	Name.	Amount.	
1905.				
Oct.	25. 1.	John G. Peck, Power Plant	$17 90	
Dec.	6. 2.	Wicker Lumber Co., Power Plant	62 12	
				$80 02

Abstract No. 2.

1906.				
Feb.	2. 3.	Elderfield-Hartshorn Hardware Co., Power Plant	$18 18	
March	1. 4.	Pay-roll, February, 1906	191 75	
	31. 5.	Wicker Lumber Co., Power Plant	79 39	
	6.	Dobbie Foundry and Machine Co., Power Plant	10 00	
				$299 32

Abstract No. 3.

June	30. 7.	Dobbie Foundry and Machine Co., Power Plant	$2,620 00	
				$2,620 00

CHAPTER 686, LAWS OF 1906.

Abstract No. 1.

Aug.	3. 1.	Pay-roll, repairs to bridges	$99 00	
	2.	Wicker Lumber Co., repairs to bridges.	140 28	
Sept.	1. 3.	P. C. Flynn & Son, repairs to bridges	289 50	
				$528 78

REMITTANCE TO STATE TREASURER.

1905.				
Nov.	3.	Draft for October receipts	$731 70	
Dec.	1.	Draft for November receipts	143 70	
1906.				
Jan.	2.	Draft for December receipts	112 20	
Feb.	2.	Draft for January receipts	73 45	
May	2.	Draft for April receipts	157 00	
June	1.	Draft for May receipts	503 50	
July	3.	Draft for June receipts	1,134 40	
Aug.	2.	Draft for July receipts	3,456 95	
Sept.	1.	Draft for August receipts	5,375 15	
Oct.	1.	Draft for September receipts	3,483 35	
				$15,171 40
		Total		$43,691 35

CLASSIFICATION OF ACCOUNTS.

	Appropriations.	Expended.	Balances.
Salary of Superintendent	$2,400 00	$2,400 00	
Salary of two operators, Inclined Railway	1,800 00	1,800 00	
Salaries of ticket man, janitor and watchman at Inclined Railway	2,500 00	2,498 75	$1 25
Salaries of policemen and watchmen on Goat Island bridge	4,877 50	4,877 46	04
Salaries of Administration Building employees and janitor's supplies	1,700 00	1,699 91	09
Commissioners' expenses, Superintendent's traveling and office expenses	1,600 00	1,596 21	3 79
Wages of employees and purchase of supplies, tools, etc	10,122 50	10,119 50	3 00
	$25,000 00	$24,991 83	$8 17

EDWARD H. PERRY,
Treasurer.

We the undersigned, hereby certify that we have examined the foregoing report of the Treasurer for the fiscal year ended September 30, 1906, the vouchers and other papers, and we find the report and accompanying documents correct, and that the Treasurer has properly accounted for all moneys received and disbursed by him during the fiscal year ended September 30, 1906.

THOMAS P. KINGSFORD,
ALEXANDER J. PORTER,
Auditing Committee, Commissioners of the State Reservation at Niagara.

RATE OF RECESSION OF NIAGARA FALLS

By G. K. Gilbert,

ACCOMPANIED BY A REPORT ON THE SURVEY OF THE CREST

By W. Carvel Hall.

THE HORSESHOE.

Date of photograph, about 1886. The head of the Horseshoe curve recedes more rapidly than any other part of the cataract. The notch in its farther margin was developed after 1827.

RATE OF RECESSION OF NIAGARA FALLS

By G. K. Gilbert.

INTRODUCTION.

The erosive work of the cataract of Niagara is exceptionally rapid. This depends primarily on the great power of the falling water, but in part on the character of the local geologic structure. The rocks are stratified and lie nearly level. The upper layers are of limestone, strong and resistant; the lower, consisting chiefly of shale, are comparatively weak and yielding. As the shales are worn away below the limestone beds are undermined, so that their edges project like a cornice and are deprived of support. From time to time they yield to the force of their own weight and fall away in large blocks. Each rock fall causes a jar of the ground which is perceived by people in the vicinity, and results in a modification of the crest of the cataract which is readily seen by anyone familiar with its outline. Such changes of the crest have been observed from time to time ever since the neighboring banks of the river were occupied by white men. It is highly probable that they were also observed by Indians before the advent of white men, but on this point I have made no inquiries, as Indian traditions are not likely to be sufficiently definite to aid in determining the rate of progressive change in the position of the cataract.

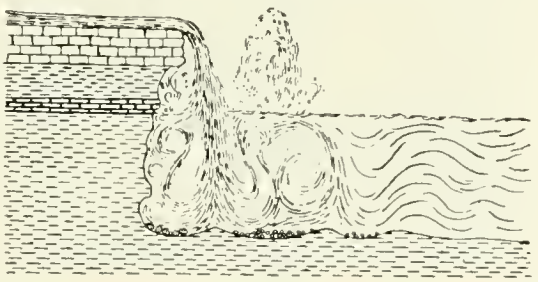


Fig. 1.—Diagrammatic profile of Horseshoe Fall, illustrating mode of erosion and recession.

The surface of Lake Erie is 325 feet higher than the surface of Lake Ontario. The belt of land between them includes two plains, of which the higher and broader is raised but little above the level of Lake Erie, and the lower slopes gently to the shore of Lake Ontario. The descent from the upper to the lower is abrupt, constituting a line of cliffs parallel to the shore of Ontario and known as the Niagara escarpment. The river, issuing from Lake Erie at Buffalo, flows at first on the upper plain. It is there broad and

comparatively shallow and has no valley. At the falls it suddenly drops into the head of a narrow gorge which is six miles long and extends to the escarpment. Within the gorge it is narrow and contained by steep walls. Near the head of the gorge the water is deep, the current moderate, and the descent small, but farther on are fierce rapids with steep descent. Some of these relations are shown in fig. 2. As the falls are at the head of the gorge, it is evident that their recession makes the gorge longer.

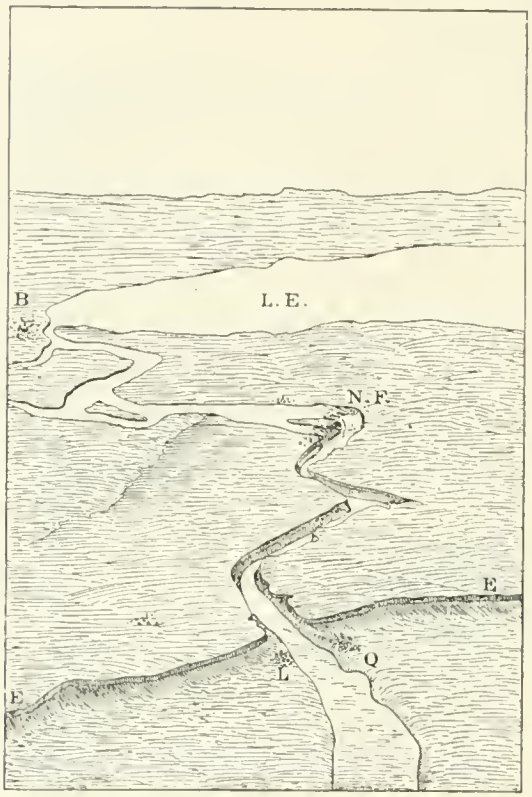


FIG. 2.—Bird's-eye view of Niagara River. The view is southward, or upstream, from a point above the shore of Lake Ontario, and shows the two plains, the escarpment, and the gorge. B, Buffalo. NF, Niagara Falls. L, Lewiston. Q, Queenston. EE, Niagara escarpment.

Among the early observers of the falls was McCauslin, who remained there from 1774 to 1783. After describing the escarpment at Queenston he says:[a]

> It is universally believed that the cataract was originally at this ridge, and that it has by degrees worn away and broke down the rock for the space of these six or seven miles. Some have supposed that from these appearances, conjectures might be formed of the age of this part of the world. To enter upon such a calculation, it would previously be necessary to ascertain how much the fall had retired in a hundred years, or any other certain period. Suppose that we were even in possession of such a fact, still the conclusions drawn from it would be liable to the greatest uncertainty, as it is evident that the space of rock broke down and worn away in a certain number of years would not always be the same. The more or less hardness and brittleness of the rock in different parts; the greater or less severity of the frosts in different years; and the quantities of water that flowed at different periods in the cataract of the river, would all occasion considerable variations. This retrocession of the Falls does not by any means go on so quickly as some have imagined. During nine years that I have remained at Niagara, very few pieces of the rock have fallen down which were large enough to make any sensible alteration in the brink; and in the space of two years I could not perceive, by a pretty accurate measurement, that the North-East brink had in the least receded. If we adopt the opinion of the Falls

[a] McCauslin, Robert, An account of an earthy substance found near the Falls of Niagara and vulgarly called the spray of the falls, together with some remarks on the falls: Trans. Am. Philos. Soc., vol. 3, 1793. (Read October 16, 1789.) The passage cited is on pages 23-24.

having retired six miles, and if we suppose the world to be 5,700 years old, this will give about sixty-six inches and a half for a year, or sixteen yards and two-thirds for nine years, which I can venture to say has not been the case since 1774.

Enys, who visited the cataract in 1787, quotes the opinion of residents that "the Falls have altered their position or retreated since the memory of men,"[a] but dissents from the view (which seems also to be generally entertained) that the original situation of the Falls was at Queenston.

Weld, whose visit to the falls was in 1796, says that "even within the memory of many of the present inhabitants of the country, the falls have receded several yards."[b] He favors the theory that the gorge from Lewiston to the falls was made by the falls, and his discussion of the subject shows him to have been a close observer and clear thinker.

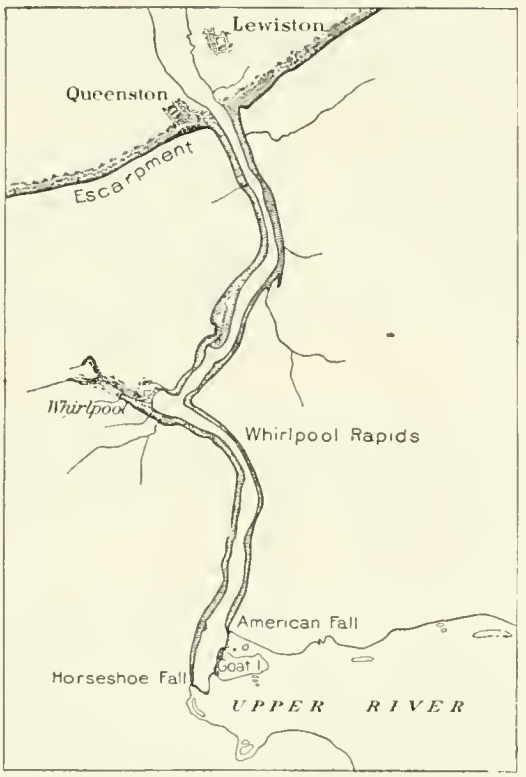


FIG. 3.—Map of the Niagara gorge, showing its relations to the falls and the escarpment.

Volney two years later repeats the general statement of observed recession, and adds:[c]

> If the European colonists or travellers, to whom this region has been accessible for a century and a half, had made careful memorandums, from time to time, of the state of the fall, we should, by this time, have been able to trace the progress of those revolutions, which are easily proved to have taken place, by vestiges and indications which present themselves at every step.

And still further, in a footnote:[d]

> It is extremely desirable that the government of the United States, at present under the direction of a friend to the arts and sciences [Jefferson],

[a] Rept. Canadian Archives, 1886 (published 1887), p. cexxxii.

[b] Weld, Isaac, jr., Travels through the States of North America and the Provinces of Upper and Lower Canada during the years 1795, 1796, and 1797, London, 1799, p. 320.

[c] Volney, C. F., A view of the soil and climate of the United States of America, etc., translated by C. B. Brown, Philadelphia, 1804, p. 92.

[d] Op. cit.

should order to be drawn up an exact description of the present state of the cataract. This statement, compared with subsequent appearances, observed from time to time, would enable us to trace with certainty the changes that may hereafter take place.

Francis Hall, 1816, says: [c]

The name of "the Horse shoe," hitherto given to the larger Fall, is no longer applicable: it has become an acute angle. * * * An officer who had been stationed in the neighbourhood thirty years, pointed out to me the alteration which had taken place in the centre of the Fall, which he estimated at about eighteen feet in the thirty years.

Gilpin, whose visit was probably a few years later, says: [a]

The toe of the shoe, however, is now an angle, rather than a curve, but the inhabitants and early visitors affirm that it was formerly more round, and has gradually assumed its present angular form, within their recollection. * * * Mr. Forsyth, who has resided upon the spot for more than forty years, says, that within his recollection, the centre of this fall has receded from ten to fifteen yards; and, as some intelligent travellers have placed upright a few large stones in front of the hotel, which, when taken in a line, point exactly to that spot, it will of course be ascertained, at the end of a certain number of years, how much this centre recedes annually.

Schoolcraft, whose visit was in 1820, describes the undermining of the limestone by the fretting away of the shale, and mentions with approval the theory that the falls were anciently at Lewiston. He says: [b]

* * * The wasting effects of the water, and the yielding nature of the rocks, remain the same, and manifest the slow process of a change, at the present period, as to position, height, form, division of column and other characters, which form the outlines of the great scene; and this change is probably sufficiently rapid in its operation, if minute observations were taken, to imprint a different character upon the Falls, at the close of every century. Nothing in the examination of the geological constitution, and mineral strata of our continent, conveys a more striking illustration of its remote antiquity, (still doubted by many) than a consideration of the time, it must have required for the waters of Niagara, to have worn their channel, for such an immense distance, through the rock. It is true, we are in possession of no certain data, for estimating the annual rate of their progress, or for comparing the results with the Mosaic history of the earth. All that can be presumed is, that this progress, is now as rapid, as it was in former ages. * * * Maps and descriptions are now extant, which will enable us to fix the rate of its progress, on the expiration of the present century, and we should not

c Hall, Lieut. Francis, Travels in Canada, and the United States, in 1816 and 1817. Boston; republished from the London edition by Wells & Lilly, 1818, p. 144.

a Gilpin, H. D., A northern tour; being a guide to Saratoga, Lake George, Niagara, Canada, Boston, etc., Philadelphia, 1825, p. 149.

b Schoolcraft, Henry R., Narrative journal of travels, etc., made in 1820. Albany, 1821, pp. 45-47.

be disappointed in our anticipations, if its progress is found, greatly to exceed the prevalent expectation. To aid in the determination, the Island of Iris, which extends from the brink of the Fall, up the river, and which is now connected with the shore, by a wooden bridge, appears to present great facilities. A simple measurement of its length, with a monument for recording it at its head, would convert it into a graduated scale, and the point of the indentation of the Horse Shoe Fall, could, in like manner, be perpetuated on either shore, by a series of corresponding celestial observations, for determining the longitude of the extreme point of that incurvation. Distant ages would thus be furnished with data, the precision of which, would probably enable them to throw new and important lights on the history of the earth, and the changes it has undergone. Is this suggestion of too visionary a nature, to merit the consideration of geological societies?

Capt. Basil Hall, R. M., made a study of the cataract in 1827, and two years later published an excellent description, from which I quote:[c]

In the course of our investigations and rambles, we met a gentleman who had resided for the last thirty-six years in this neighborhood — happy mortal! He told us that the Great Horse Shoe Fall had, within his memory, gone back forty or fifty yards — that is to say, the edge, or arch of the rock over which the water poured, had broken down from time to time to that extent. This account was corroborated by that of another gentleman, who had been resident on the spot for forty years.

As these statements came from persons of good authority, I was led to examine the geological circumstances more minutely; for I could not conceive it possible, that the mere wearing of the water could perform such rapid changes upon hard lime-stone. The explanation is very simple, however, when the nature of the different strata is attended to. In the first place, they are laid exactly horizontal, the top stratum being a compact calcareous rock. In the next place, I observed, that in proportion as the examination is carried downwards, the strata are found to be less and less indurated, till, at the distance of a hundred feet from the topmost stratum, the rock turns to a sort of loose shale, which crumbles to pieces under the touch; and is rapidly worn away by the action of the violent blasts of wind, rising out of the pool into which this enormous cascade is projected.

In process of time, as the lower strata are fairly eaten or worn away, the upper part of the rock must be left without a foundation. But owing to the tough nature of the upper strata, they continue to project a long way over before they break down. There must come periods, however, every now and then, when the overhanging rock, with such an immense load of water on its shoulders, will give way, and the crest, or edge, of the Fall will recede a certain distance. At the time of our visit, the top of the rock, or that over which the river was directed, overhung the base, according to the rough estimate I made, between 35 and 40 feet, thus forming a hollow space, or cave, between the falling water and the face of the rock.

While the above lines were actually in the printer's hands, my eye was accidentally caught by the following paragraph in a newspaper:—

[c] Hall, Capt. Basil, Travels in North America in the years 1827 and 1828, vol. 1, Edinburgh, 1829, pp. 195–197.

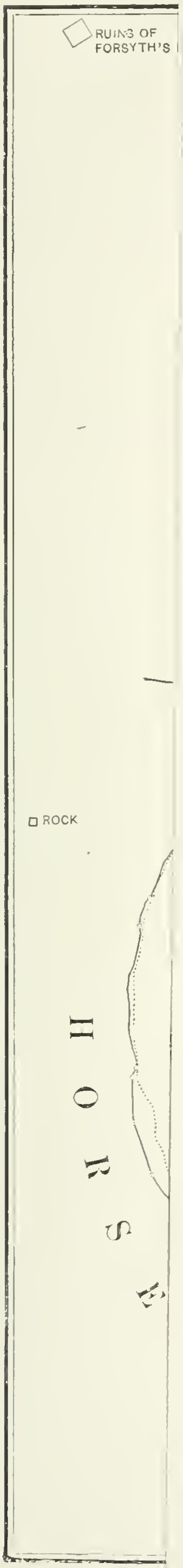
"NIAGARA FALLS.—A letter from a gentleman at that place, dated Dec. 30, 1828, states, that on the Sunday evening preceding, about 9 o'clock, two or three successive shocks or concussions were felt, the second of which was accompanied by an unusual rushing sound of the waters. The next morning it was discovered, that a large portion of the rock in the bed of the river, at the distance of about two-fifths from the Canada shore to the extreme angle of the Horse Shoe, had broken off, and fallen into the abyss below. The whole aspect of the Falls is said to be much changed by this convulsion. A course of high winds for several days previous to its occurrence, producing an accumulation of water in the river, is supposed to have been the immediate cause. This gradual crumbling away of the rock over which the Niagara is precipitated, adds plausibility to the conjecture, that the Falls were once as low down as Lewiston, and have for centuries been travelling up towards their present position."

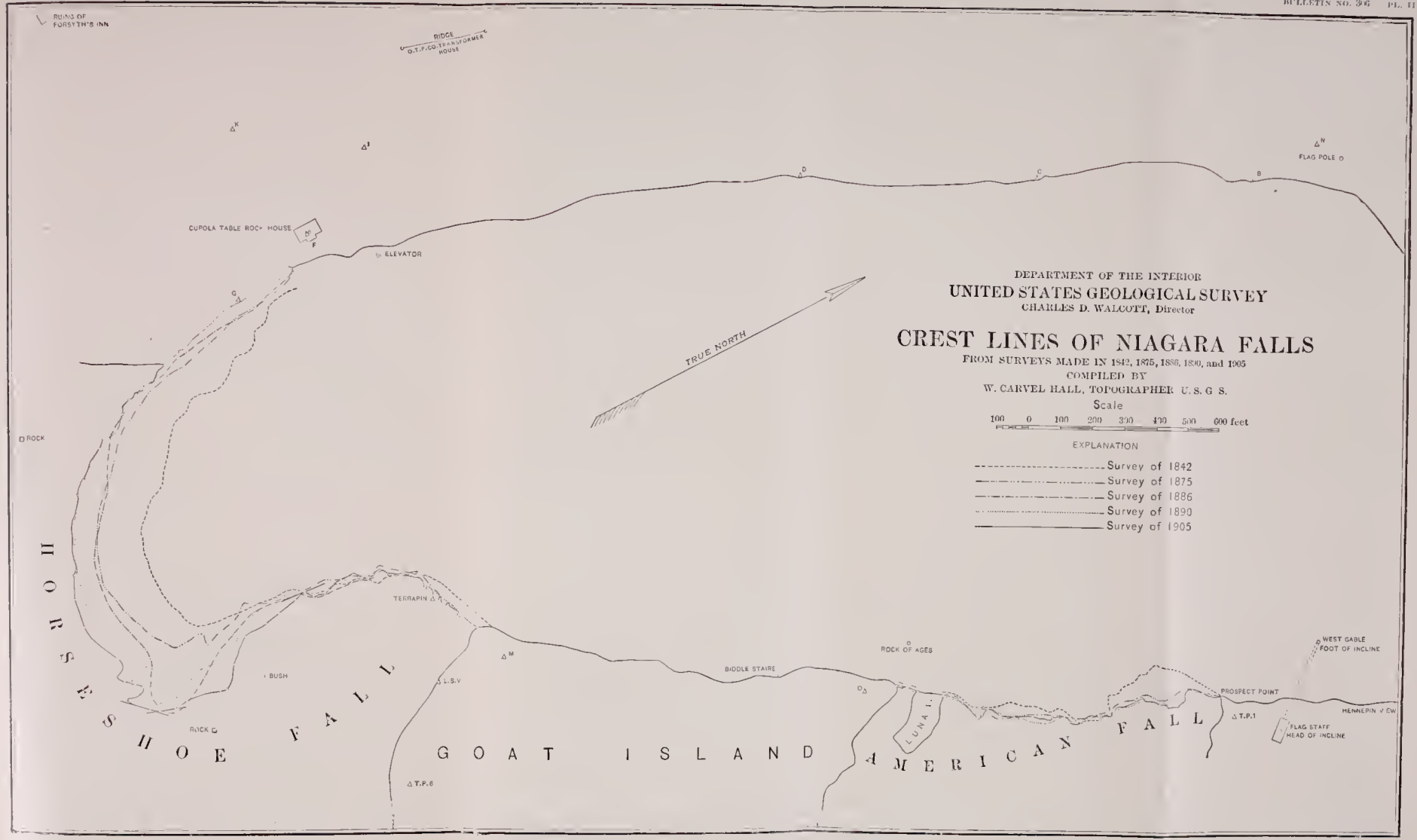
Captain Hall also published a series of sketches of the falls,[a] and as these were made with the camera lucida they have exceptional value. They, in fact, constitute the first record bearing on the rate of recession from which measurements can profitably be made, and there is frequent reference to them in other parts of this paper.

The preceding citations serve to show the early development of three ideas: (1) That the crest of the Horseshoe Fall is receding upstream, the recession being caused by the energy of the cataract; (2) that the gorge before the falls was created by this process of recession, the position of the falls having originally been where the mouth of the gorge now is, and (3) that it is possible, by sufficiently accurate observations, to determine the rate at which the change is taking place.

Associated with the idea of measuring the rate of recession was that of applying it to the determination of the time consumed by the river in the making of the gorge. By some of the earlier writers the age of the gorge was obscurely connected with the age of the world as estimated from Biblical data; by others it was recognized as a small fraction of geologic time. With the progress of knowledge of the local geologic history there was increasing interest in the time estimates for the river, and the various conditions affecting the estimate came to be scrutinized with much care. As developed by careful study, the problem proved to be complex and difficult. It came to be recognized not only that the rate of recession in different parts of the gorge must have varied

[a] Hall, Capt. Basil, Forty etchings, from sketches made with the camera lucida, in North America, in 1827 and 1828, Cadell and Co., Edinburgh, 1829, pls. 1–5.


RUINS OF
FORSYTH'S
ROCK
HORSE


RUINS OF FORSYTH'S INN
RIDGE
O.T.F.CO. TRANSFORMER HOUSE
CUPOLA TABLE ROCK HOUSE
ELEVATOR
FLAG POLE
TRUE NORTH
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, Director
CREST LINES OF NIAGARA FALLS
FROM SURVEYS MADE IN 1842, 1875, 1886, 1890, and 1905
COMPILED BY
W. CARVEL HALL, TOPOGRAPHER U. S. G. S.
Scale
100 0 100 200 300 400 500 600 feet
EXPLANATION
Survey of 1842
Survey of 1875
Survey of 1886
Survey of 1890
Survey of 1905
ROCK
TERRAPIN
BUSH
ROCK
HORSESHOE FALL
T.P.6
L.S.V
BIDDLE STAIRS
ROCK OF AGES
GOAT ISLAND
LUNA I.
AMERICAN FALL
PROSPECT POINT
T.P.1
WEST GABLE
FOOT OF INCLINE
HENNEPIN VIEW
FLAG STAFF
HEAD OF INCLINE

with the height of the cataract, the temporary width of the stream, and the thickness of the capping limestone, which is different in different places, but also in a very important way with the volume of water carried by the river, which has been subject to extreme fluctuations. The influence of these various conditions assumed prominence in the discussion, and altho the rate of present recession came to be fairly well known, opinions still differed widely as to the total period represented by the gorge. The age of the gorge is outside the scope of the present paper, and the subject is here mentioned only to show the basis of the strong interest which has been felt in the determination of the present rate of recession.

In 1841 James Hall, then geologist of the fourth district of New York, undertook the preparation of an authoritative map of the crest of the falls, and employed for that purpose E. L. Blackwell, a civil engineer. The work was completed in the autumn of 1842, at which time a series of monuments were established at the principal trigonometric points. The map was published the following year,[a] together with descriptions of the monuments and a table of compass bearings from the various trigonometric points to objects whose positions were determined by the method of intersection. It was the purpose of this survey to make definite record of the existing position of the crest line and connect this record with permanent monuments, so that by means of a similar survey at some future time the extent of changes might be determined. This purpose it has served. Monuments then placed have been used as starting points in subsequent surveys, and two of them are still extant.

As this work by our great master in geology marks a turning point in the subject — the change from the vague to the definite — I quote a few passages to show his point of view:

> Among the phenomena of waterfalls and river gorges, the Cataract of Niagara is justly regarded as holding the first rank, and as standing an index in the path of time, by which the influence of numberless ages upon the surface of our planet may be recorded. Its present, its former and its prospective conditions have engaged the investigation and speculation of many philosophers. The possible consequences of its entire reduction, and the drainage of the upper lakes, have excited the wonder and the apprehension of many. The estimated time of its recession has sprinkled grey hairs among the fresh locks

[a] Nat. Hist. New York, pt. 4, Geology, 1843, opp. p. 402.

of the young and blooming earth, and alarmed those who would consider her still youthful in years.

But amid all these speculations, Niagara still remains; the thunder of its cataract still reverberates through its deep chasms, and its ocean of waters still rolls on as, unknown to the white man, it rolled a thousand years ago. When we come to the investigation of facts, we find that, except to travellers and the aborigines, Niagara was unknown until within the last fifty years; and that even during this time no accurate observations have been made, no monument erected to determine whether the falls are retrograding or not. The testimony of living witnesses and historical evidence unite in confirming the opinion that the water is wearing away the rock, and that the outline of the falls has changed. From these general observations, it has been estimated that they have receded at the rate of about forty feet in fifty years. Without pretending to question the accuracy of this or any other estimate of the kind, or to establish any rate of retrogression in the falls, we may examine its present, and from numerous facts infer its past condition; and from these we are entitled to draw an inference for the future, though without specifying time.[a]

The foresight with which he planned the survey and record for the specific purpose is shown by the statement with which the map is introduced:

The accompanying map has been constructed from a very careful survey by Mr. Blackwell, giving the present position and outline of both falls, and the river banks upon either side. Upon application to His Excellency Sir Charles Bagot, late Governor-General of Canada, I was authorized to establish monuments upon the Canada shore, and was also kindly offered every other aid to promote the object of the survey. These monuments, together with those in New-York, will enable future observers to ascertain the amount of recession during any given period. In places where the rock is exposed, copper bolts have been fixed, and in other places hewn stone monuments. The starting point for all these observations is a copper bolt fixed in the rock on the north side, near the edge of the American fall. * * *[b]

In 1875 the second survey of the crest line was made by the United States Lake Survey under the direction of Maj. C. B. Comstock, the field work being by F. M. Towar. The United States Geological Survey undertook the third survey, which was made by Robert S. Woodward in 1886. The fourth survey was made in 1890, by A. S. Kibbe, under the direction of John Bogart, State Engineer of New York, and a very full report was published. In this report the maps of the three preceding surveys are republished, and the crest lines given by those surveys are also

[a] Nat. Hist. New York, pt. 1, Geology, 1843, p. 383.
[b] Op. cit., p. 402.

placed on the new map.[c] The fifth survey was made in the spring of 1905, by the United States Geological Survey and the State Engineer of New York, the work being done by W. Carvel Hall, and his report follows this paper.

The crest lines determined by the five successive surveys are platted together on Pl. II, and their examination demonstrates clearly the gradual retreat of the crest of the Horseshoe Fall. Each mapped crest line is, on the whole, farther upstream than its predecessor, and their interspaces are roughly comparable with the time intervals between the making of the surveys; but each of these statements requires qualification. The region of maximum retreat has shifted from one part to another of the crest during the period of observation, so that in any one part the rate of retreat has been irregular; and when the chart is closely scrutinized it is found that the different lines overlap one another at various points, so that if all of them were rigidly accurate their record would show that the crest line had in places advanced downstream, instead of retreating. In the report of the last survey it is suggested that some of these discrepancies may be explained by an actual sliding forward of upper layers of limestone before they toppled over the brink, but the greater discrepancies can not be explained in this way, and the discrepancies as a whole are unquestionably due to errors in the topographic work, chiefly thru failure to identify points previously sighted when intersecting bearings were taken. Fortunately, they are not of such character or extent as to impair the general conclusions to be drawn from the work; but they serve to caution the student against any over-refinement in the discussion of results.

The Erie canal is supplied with water from the Niagara river at Buffalo, the Welland canal is supplied from Lake Erie, and the Chicago Drainage canal draws water from Lake Michigan. All the water thus diverted is withdrawn from the cataract. So also is water diverted from the river above the falls for factory purposes and for use in the generation of electricity. In recent years the diversion for electric power has rapidly increased, and existing charters authorize so large a draft upon the river that it has come to be recognized that the scenic value of the cataract is in

[c] Seventh Ann. Rept. Comrs. State Res. Niagara for fiscal year October 1, 1889, to September 30, 1890, Albany, 1891.

peril. A vigorous protest has been made by lovers of natural beauty, and negotiations are in progress for an international agreement to check and regulate the economic exploitation of the river. Whatever the outcome of these negotiations, there is no reason to expect that the natural flow of the river will be restored, and it is believed that from this time onward the natural conditions will be so far interfered with as to modify the rate of recession. As the geologist is primarily interested in the natural rate of recession, the present time is opportune for a summing up of the data. In fact, the survey of 1905 was ordered in view of the change of conditions from natural to artificial.*a*

THE HORSESHOE FALL.

The Horseshoe Fall is at the head of the gorge. From its edges the walls of the gorge run northeastward approximately parallel. The American Fall is at the side of the gorge, 2,500 feet from its head, and is separated from the Horseshoe Fall by Goat Island. A few hundred years ago the two falls were together, the position of the united cataract being somewhere in the neighborhood of the present American Fall. The subsequent retreat of the Horseshoe Fall has had the effect of lengthening the gorge, but the American Fall has not in the same time made an alcove in the side of the gorge. With reference therefore to the question of the age of the gorge, it is the Horseshoe Fall whose rate of recession is important.

The chief data for the estimation of the rate of recession are the maps of 1842 and 1905, the time interval being sixty-three years. The outlines from those maps are shown in fig. 4. These data, like other statistical data, can be discussed in a variety of ways and made to yield widely divergent results — a fact sufficiently illustrated by earlier estimates of the rate of recession based on comparisons of the map of 1842 with that of 1875, 1886, or 1890. The following paragraphs therefore set forth somewhat fully the

a Since this paper was written it has come to my knowledge that a resurvey of the Niagara River is being made by the United States Lake Survey, the field work for the crest of the falls having been done in the summer of 1906. This will afford an additional datum on the rate of recession, but is not likely to affect the computation to a material extent. The addition of one year to the period of observation will probably be offset by changes occurring within that year. Inspecting the Horseshoe curve in August, 1906, I was confident that a salient near the angle of the curve, which was recorded by the surveys of 1890 and 1905, did not then exist. — G. K. G.

HORSESHOE FALL IN 1827.

Copy of sketch by Capt. Basil Hall, made with camera lucida, from veranda of Forsyth's Hotel.

methods here used, with the principal considerations on which they are based.

In the lengthening of the gorge the river does its principal work in that part of the Horseshoe curve where the current is deepest. The agitation of the plunging water is there so powerful as to roll about the fallen blocks of limestone, using them as tools to grind the shale, and at the same time breaking them up and eventually washing them downstream. The scour maintains a deep hollow beneath this part of the fall, a hollow whose depth is greater than the height of the fall. (Fig. 1, p. 41.) At the sides of the channel, especially near the right bank, where the sheet of falling water is comparatively thin, the fallen blocks are not cleared away, but cumber the base of the cliff. (Pl. X, p. 61.) As the cataract retreats it leaves behind it a deep channel, or elongated pool, in which the current is slow. Below the cataract the gorge is widened at top by the falling away of its banks. When the shale is exposed to the air it becomes subject to frost action, and for a time the limestone ledge above continues to be undermined, but a practical limit is reached as soon as the talus of fallen material covers the slopes of shale, and thereafter the change is exceedingly slow. The real lengthening of the gorge is along that portion of the Horseshoe where the sheet of falling water is heavy enough to clear away the debris and maintain a deep pool. The retreat of the cliff on either side of this portion is secondary, and appears to have little or no bearing on the question of the rate at which the gorge is growing longer. I have therefore restricted attention to the central part of the Horseshoe curve.

As the two crest lines compared are irregular in outline, a certain confusion arises if the recession of different parts is considered separately. At one place the recession seems to have one direction, at another place to have another direction, and various complications ensue when attempt is made to combine measurements made in different directions. In view of this difficulty it has appeared to me both convenient and legitimate to assume some one direction as the general direction of recession and at all points measure the amount of recession on lines parallel to that direction. From an inspection of the crest lines as wholes and in their relation to each other I have inferred such a general direction of re-

cession, and assuming it to apply to the entire central tract of the Horseshoe, have drawn the system of parallel lines seen in fig. 4. There are six of these lines, each extending from the crest line of 1842 to that of 1905. Their interspaces, according to the scale of the map, are 100 feet wide. The average length of these lines represents approximately the average recession of the cataract in the part where the sheet of falling water is heaviest. Their lengths are, severally, 430, 292, 260, 276, 317, and 412 feet, giving an average length of 331 feet. This distance divided by the number of years, 63, gives as the average annual recession 5.3 feet.

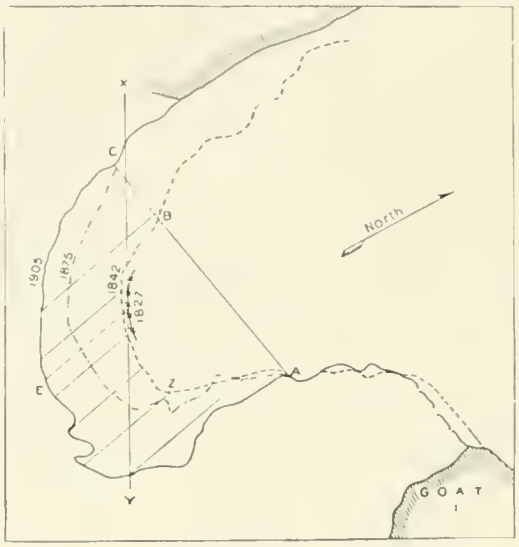


FIG. 4.— Outlines of Horseshoe Fall in 1842, 1875, and 1905, with lines used in computing the rate of recession. The line of crosses suggests a position of part of the crest in 1827.

A somewhat allied method of estimate is concerned with areas. Still restricting attention to the central portion of the Horseshoe curve, I have drawn a line from A, the point at which the two crest lines begin to diverge, to the opposite shore at C, making its direction lie at right angles to the general direction of recession. The area contained between the two crest lines AZB and AEC, and limited downstream by the straight line AC, may be regarded as the area removed by the central portion of the fall between 1842 and 1905. The corresponding width of this part of the gorge in 1842 was AB, 570 feet; in 1905 AC, 760 feet. The mean of these, 665 feet, is assumed as the average width for the intervening period. The indicated area between the crest lines was found by measurement to be 223,000 square feet, and this quantity being divided by 665 feet, gives 335 feet as the average recession in a direction at right angles to AC. Dividing, as before, by 63, the number of years, I obtain again as an estimate of the average annual rate 5.3 feet.

The close coincidence of these two results is accidental, altho a general agreement was to be expected because the assumptions underlying the computations are harmonious. As already stated,

HORSESHOE FALL IN 1895.

Photograph from same point as sketch, Pl. IV. The island at S is common to the two views. Their comparison shows the recession of the fall and the change in its outline.

materially different results may be obtained with different assumptions.

Less harmonious results are obtained if the period from 1842 to 1905 is divided into parts and the parts are separately computed. Their discordance has two sources which can not be fully discriminated. From the nature of the case the rate of recession is not uniform. The distance to which the cornice of limestone comes to project before it is broken away depends not only on the strength of the rock, but on the local arrangement of vertical joints by which it is traversed, and also to some extent on the shape of the temporary outline of the crest. The fall of rock is therefore irregular and only obscurely rhythmic. In a period measured by centuries these irregularities would have little influence on the general average, but for short periods their influence may be great. A second source of discrepancy in the results lies in the inaccuracy of the surveys. Even where the sheet of water is so thin that the rock is visible through it there is some liability to error, and where the topographer could see only the curved and changing surface of the rushing water his observations were necessarily somewhat indefinite. Two observers might in fact differ by several feet in their estimate of the actual position of the rock crest over which the water pours. The only results for shorter periods which it seems advantageous to place on record are those which use the map of 1875 in connection with the maps of 1842 and 1905. This approximately halves the whole period of sixty-three years, the earlier part being thirty-three years in length and the later part thirty years. By applying to these two divisions the methods already described for the whole period, and employing the same ordinates and the same limiting line, the following results were obtained:

Rates of recession computed for various periods and by different methods.

Limiting Dates.	Length of period.	Average Annual Recession.	
		Computed by parallel ordinates.	Computed by areas.
	Years.	*Feet.*	*Feet.*
1842–1875	33	4.0	4.4
1875–1905	30	6.6	5.6
1842–1905	63	5.3	5.3

The indication is that during the thirty years following 1875 the lengthening of the gorge went on at a somewhat faster rate than during a similar period preceding that date. While it is quite possible that the apparent variation in the rate is sufficiently accounted for by the irregularity of the breaking away of the limestone sill, it is also possible that the rate has been influenced by a special condition affecting the mode of recession. A change in the outline of the fall which was mentioned nearly a century ago as diminishing its resemblance to a horseshoe consisted in the development of an angle near the head of the curve and on the side toward Goat Island (Z, fig. 4). Within the last thirty years the recession has been especially rapid in that angle, and there has developed a deep recess or notch. This appears to have been occasioned by a local weakness of the limestone, presumably its subdivision by a belt of vertical joints. Within the notch the mode of recession has been so far modified that the upper layers of limestone have been removed before the lower, so that at certain stages of the process the water after falling from the crest has been caught by a shelf. The configuration can be better understood by an examination of Pl. I (p. 41), which is based on a photograph made in or near the year 1886. Whatever the method of erosion in the notch, it appears to be superadded to the general erosion by undermining, and an acceleration of the rate may plausibly be ascribed to it.

If we regard the general method of recession by the process of sapping or undermining as normal, and the influence of joint systems as exceptional and temporary, the rate of recession computed for the period from 1842 to 1875 should be accepted as normal and the best available for use in geologic computations; but this involves the assumption that the limestone ledge was not affected in other parts of the gorge by belts of weakness similar to the one which has been exposed during the last few decades. It seems to me better, on the whole, to assume that the limestone eroded between 1842 and 1905 is fairly representative, so far as strength is concerned, of all that portion of the limestone ledge in which the cataract has done its work.

The maps of 1842 and 1905 represent the earliest and latest surveys, but do not include quite all the data worthy of consideration in this connection. A sketch by Basil Hall, made

AMERICAN FALL IN 1827.

Copy of sketch by Capt. Basil Hall, made with camera lucida, from Goat Island. For explanation of broken line *A* see page 19.

AMERICAN FALL IN 1895.

Photograph from balcony just above view point of Pl. V.

with the aid of a camera lucida, in 1827, has a claim for accuracy by no means to be disregarded. In the use of the camera lucida the draftsman sees the landscape as though faintly pictured on a sheet of paper, and at the same time sees the pencil with which he traces its outlines. Before photography this method was the most accurate known for recording the outlines of a landscape, and in skillful hands it gives results of notable precision. There is much internal evidence that Captain Hall's sketches at Niagara were made with care and fidelity, and in view of these facts I have thought it worth while to endeavor to combine his record with the records by mapping. He tells us that his principal sketch of the Horseshoe Fall (Pl. III) was made from the upper veranda of Forsyth's Inn, on the Canadian shore, and the relation of the veranda to the inn is shown by a contemporary drawing by Mrs. Trollope.[a] The inn itself long since disappeared, but its position is still marked by the ruins of its foundations. Through the courtesy of Mr. James Wilson, Superintendent of Victoria Park, who caused the necessary scaffolding to be constructed, I was enabled, in 1895, to place a photographic camera within a few feet of the position once occupied by the camera lucida, and this position has also been located on the map of 1905 (Pl. II, p. 47). A comparison of the two pictures made from that position yielded the identification of a common point on one of the Three Sister Islands (S, Pl. III), and with the aid of the orientation thus secured it became possible to draw upon the modern map the line XY in fig. 4, representing a direction from Captain Hall's point of view tangent to the head of the Horseshoe Fall. It will be observed that this line passes very near to the head of the curve as drawn in the map of 1842, the implication being that at the head of the gorge very little recession had occurred in the fifteen years intervening between 1827 and 1842. I am not sure that this single line, obtained by so circuitous a method, should be allowed to influence the result based on two topographic surveys, but to whatever extent it is given consideration its tendency is to reduce the estimate of the annual rate.

[a] Trollope, Mrs., Domestic manners of the Americans, vol. 2, London, 1832, frontispiece.

THE AMERICAN FALL.

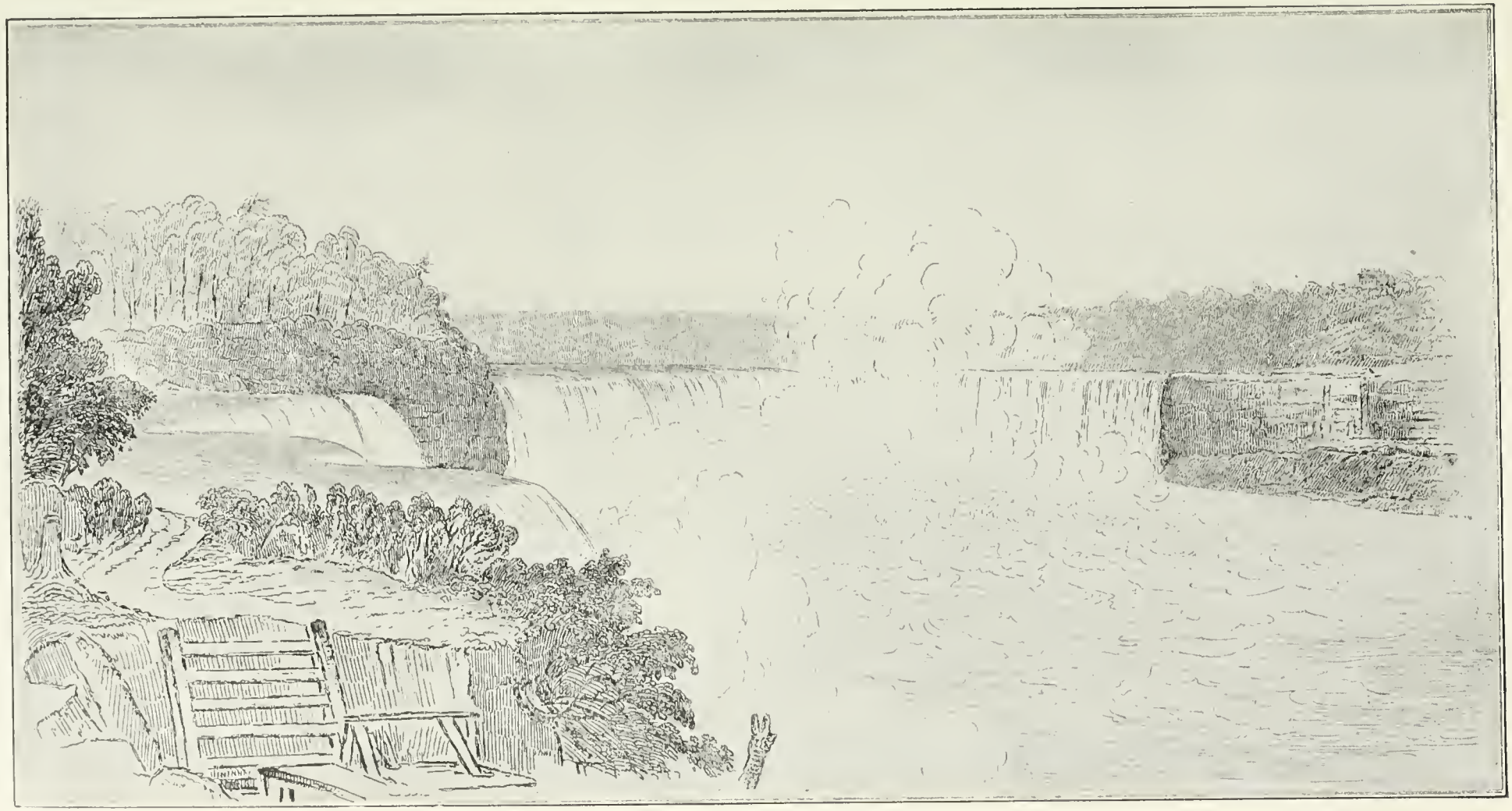
The recession of the American Fall is much slower than that of the Horseshoe. The sheet of water on its brink is comparatively thin, and the force the water acquires in falling is not sufficient to remove the larger of the limestone blocks broken from the ledge above. The blocks are therefore heaped at the base of the cliff and serve as a natural riprap to protect the shale against wear. (See Pl. XI, p. 62, and fig. 8, p. 62.) Since the Horseshoe Fall parted from the American, leaving it stranded at the side of the gorge, there has evidently been some falling away of the crest of the American Fall, else there would be no limestone blocks at its base. But as the talus increases in height it becomes more and more protective, and the rate of recession should theoretically diminish.

It has already been observed that the geologist's interest in the rate of recession applies primarily to the Horseshoe Fall, because the work of that fall makes the gorge longer. If the conditions of erosion had been uniform during the whole period of the excavation of the gorge the work of the American Fall would have little bearing on its time estimates, but the volume of the river has not always been so great as at present, and there were two epochs in the history of the gorge when the volume was very small. During those epochs the discharge of the whole river was probably not much greater than the present discharge through the American channel, so that the conditions affecting erosion were somewhat similar to those illustrated by the American Fall. For this reason it is worth while to inquire at what rate the American Fall has receded since the first precise observations on its position and contour.

Traditional information as to changes in the American Fall is summarized by Lyell:[a]

> The sudden descent of huge rocky fragments of the undermined limestone at the Horseshoe Fall, in 1828, and another at the American Fall, in 1818, are said to have shaken the adjacent country like an earthquake. According to the statement of our guide in 1841, Samuel Hooker, an indentation of about forty feet has been produced in the middle of the ledge of limestone at the lesser fall since the year 1815, so that it has begun to assume the shape of a crescent, while within the same period the Horseshoe Fall has been altered so as less to deserve its name.

[a] Lyell, Charles, Travels in North America, vol. 1, London, 1845, p. 33.



AMERICAN FALL IN 1827.

Copy of sketch by Capt. Basil Hall, with camera lucida, from American shore. The Horseshoe Fall is in the distance.

The graphic record begins with two camera lucida sketches by Basil Hall, made in 1827. One was from Goat Island, near the southern end of the crest line, the other from a point on the American shore near the northern end of the crest line. His view points were so near to the fall that he was able to represent details too small to appear in the sketch of the Horseshoe Fall. The American Fall was also mapped with the same care as the Horseshoe in 1842, 1875, 1886, 1890, and 1905. Since the time of the daguerreotype the fall has been photographed from positions similar to those occupied by Basil Hall, and in 1895 I recovered his viewpoints as nearly as practicable for the sake of making photographs which might be compared with his camera-lucida sketches. To this end I visited the localities with his sketches in hand, and endeavored to determine the view points by comparing various details of the sketches with the landscape before me. His sketches and the photographs are compared in Pls. V–VI and VII–VIII.

Examination of the combined map in Pl. II (p. 47) shows that the outlines recorded in 1875, 1886, 1890, and 1905 run closely together, the plotted lines intersecting one another at various points, while the line of 1842 coincides for only a part of the distance. A broad projection near the northern shore is indicated by the map of 1842 only, and that map also gives a more advanced position for the middle part of the crest line.

There is good reason to question the accuracy of the map of 1842, especially in the vicinity of the northern shore. The area there indicated outside the line of 1875 and later maps is 110 feet broad. As its position is close to Prospect Point, which has been a popular view point through the entire period under consideration, the falling away of such a body of rock, either gradually or all at once, could not have escaped notice, but (so far as my reading goes) current literature, including the literature of the guidebooks, is silent in regard to it. In addition to this negative evidence, there is positive information in the Basil Hall sketches. Comparing his sketch from Goat Island (Pl. V) with my photograph made from approximately the same point in 1895 (Pl. VI), it will be seen that there is essential correspondence in the distant headlands along the river. By means of these headlands I was enabled not only to establish a definite relation between the two views, but also to correlate the sketch of 1827 with the map of the gorge made in 1875, and by the aid of that map with the

various charts of the crest line. Through these comparisons it is shown that if the crest line in 1827 had had the form indicated by the map of 1842, its profile would have the position indicated by the dotted line *A* in Pl. V, and the cataract would conceal the eastern half of the gorge vista. If the great salient did not exist in 1827, it could not have existed in 1842. The conclusion appears unavoidable that the map of 1842 is wholly erroneous in its delineation of that part of the crest line near Prospect Point.

As the Basil Hall sketches have thus served to discredit a portion of the map of 1842, it is in order to inquire whether they afford a substitute for the evidence ruled out. Once more using the vesta down the gorge as the basis of correlation, and applying measurement to points recognized as identical, I have ascertained that the sketch of 1827 and the photograph of 1895 give to the extreme salient of the American Fall almost identically the same position. At that particular point the recession appears to be zero. Nearer than the salient, and appearing about one-fourth inch to the right of it, is a peculiar configuration of the crest line which seems to be common to the two views. In the photograph a dark wedge projects obliquely downward and toward the left, interrupting the body of white. In the sketch its position is occupied by a sweeping curve, less angular than the other lines representing the turn of the water. Making proper allowance for the fact that the water was unusually low in the summer of 1895, I think it quite possible that these features of the two pictures represent the same local and peculiar configuration of the rock of the crest, and the suggestion they give is that there has been no change whatever in the crest line of that portion of the American Fall since 1827.

The earliest good daguerreotype of the American Fall to which I have been able to assign a date is reproduced in Pl. IX. The gentleman who loaned me the daguerreotype appears in the picture as a child, and was able by that circumstance to fortify his memory and say that the view was taken in 1854 or 1855. Close comparison of the daguerreotype with the photograph reproduced in Pl. VIII, shows a large number of identical details ranged along the crest from the deepest recntrant to Luna Island, and proves that there was practically no recession in that part of the American Fall in the forty years from 1855 to 1895.

In Basil Hall's view from the American shore (Pl. VII) a num-

AMERICAN FALL IN 1895.

Photograph from Prospect Point, a few feet to the left of the view point of Pl. VII. Note that the American Fall has changed little and the Horseshoe Fall much.

THE AMERICAN FALL IN 1854 OR 1855.

From a daguerreotype. To be compared with the views on Pls. VII and VIII, but the view point is farther to the left and nearer the water. Many details of the crest of the American Fall are the same as in 1895, but the details of the Horseshoe Fall and the cliff profile of Goat Island differ from those of 1827 and 1895.

ber of points are sufficiently definite to be used in correlating the sketch with the map. Forsyth's Hotel appears on the bluff at the extreme right. The western edge of the Horseshoe Fall holds the same position as in 1842. The eastern edge of the Horseshoe Fall, or the right-hand profile of Goat Island, serves as another identification point, although it has doubtless fallen away a few feet. The crest of the American Fall where it adjoins Goat Island and its interruption by Luna Island are somewhat indefinite objects by reason of the curvature of the water profile, but are nevertheless serviceable, especially as their stability is assured by the general agreement of records. The nearer profile of the American Fall is assumed on the evidence just cited to have the position assigned it by the maps of 1890 and 1905. These points all appear on the map (Pl. II, p. 47). The approximate position of the artist's viewpoint is suggested by the foreground, taken in connection with various allusions in the literature.

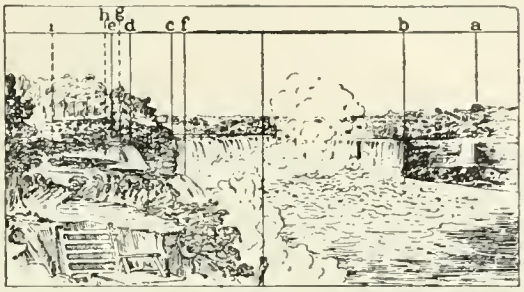


FIG. 5.—Basil Hall's sketch of American Fall from Prospect Point, with lines used in transferring its directions to map. Compare figs. 6 and 7 and Pls. VII and VIII.

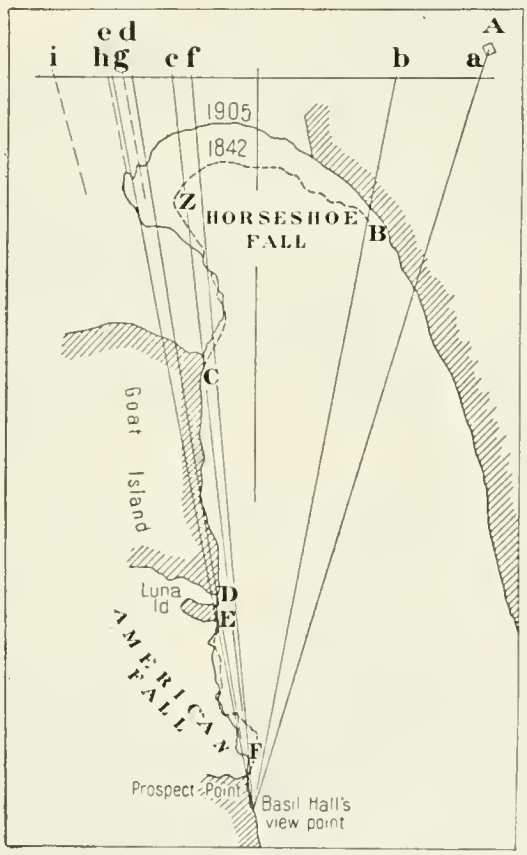


FIG. 6.—Map of Niagara Falls, with lines drawn to various points from the point occupied by Basil Hill in making a camera lucida sketch. Compare figs. 5 and 7 and Pl. VII. A, Forsyth's hotel; B, western edge of Horseshoe Fall; C, profile of Goat Island cliff; D, crest of American Fall at Goat Island; E, crest of American Fall at Luna Island; F, extreme salient on crest of American Fall.

As the geometric method of making comparison between a picture and a map may not be familiar to all readers of this paper, I venture to explain the procedure in this case, adding that similar methods were employed in other comparisons to which allusion has already been made. It is evident that the distance

of any object in the view, fig. 5, to the right or left of a central vertical line depends on the horizontal direction of the object from the viewpoint. In order to show clearly the relations of the directions of the various objects, I drew from them a series of vertical lines by which their positions were projected against a horizontal line near the top of the sketch. Lines were also drawn on the map, fig. 6, from the assumed viewpoint to the corresponding objects, and an additional line was drawn in the general direction corresponding to the middle of the picture. Then at right angles to the last-mentioned line, and at a suitable distance ascertained by trial, a line was drawn intersecting all the direction lines. The map gives the projection of the various points on a horizontal plane; the sketch gives their projection on a vertical plane. The line last drawn represents the intersection of these two planes of projection. If the map and sketch are both accurate, then the points *a*, *b*, *c*, etc., on the map should be separated by the same spaces as the points *a*, *b*, *c*, etc., at top of the sketch. As a result of the trial a very close agreement was found — as close an agreement as could be expected in view of the indefiniteness of some of the points. This agreement serves to verify the determination of the viewpoint, and also to support the conclusion that the criticism previously made of the map of 1842 is valid.

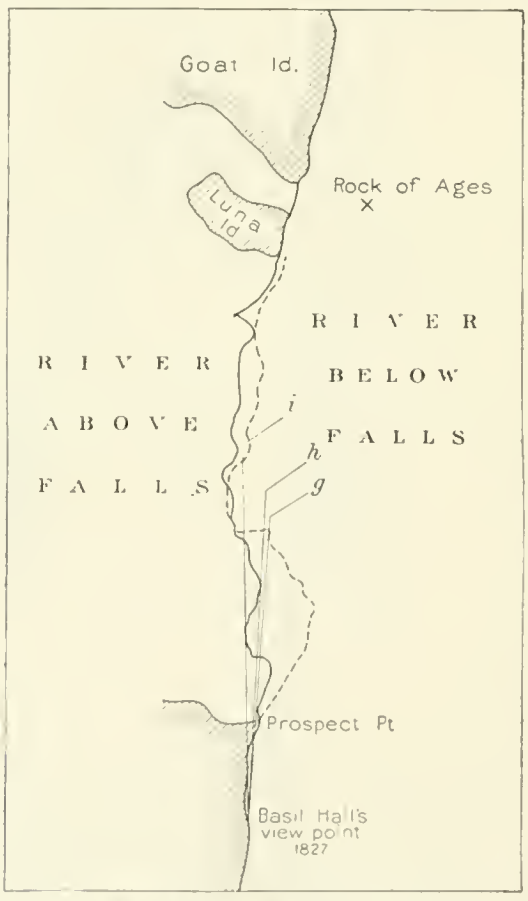


FIG. 7.— Plan of American Fall. A full line shows the crest as mapped in 1905; the broken line, as mapped in 1842; *i*, tangent to deepest reentrant as sketched by Basil Hall in 1827; *h*, tangent to reentrant nearer Prospect Point 1827; *g*, tangent to salient between two reentrants, 1827. Compare figs. 5 and 6 and Pl. VII.

Having thus established the relation of the sketch to the map, it was possible to transfer the directions of other points of the sketch to the map. Two reentrants and one salient of the fall were projected upward on the sketch, giving the points *g*,

EASTERN PART OF HORSESHOE FALL ABOUT 1885.

Shows talus of limestone blocks. At the left, near Goat Island, there was a large rock fall in 1852.

h, and *i*. These were transferred to the line on the map representing the intersection of projections, and lines were drawn from them to the viewpoint. These last-mentioned lines indicate on the map the directions of the corresponding features as recorded by the sketch of 1827, but do not show their distances from the viewpoint. They do not fix on the map the positions of the salient and re-entrants, but assign certain limits to be observed in any attempt to chart the crest line as it was in 1827. They are represented on a larger scale in fig. 7. In a general way they indicate that there has been a small amount of recession since 1827 in various parts of the crest line. Such an inference, however, should not be made without qualification, because the indicated amount of recession is of the same order of magnitude as the errors of survey and other imperfections of the data.

To give the matter quantitative statement I have tried the experiment of assuming as correct the map of 1905 and the limitations inferred from the sketches of 1827, and then interpreting other data in such way as to afford the greatest plausible recession. A computation based on these assumptions gives an average total recession since 1827 of 19.7 feet and an average annual recession of 0.25 foot. This I regard as a maximum estimate. It is highly probable that the actual average rate of recession is less than this, and it may be much less. The idea that it is much less finds support in the identical appearance of one part of the crest in 1855 and 1905 and in the apparent identity of another part in 1827 and 1895.

The matter can be approached in another way. The distance through which the Horseshoe Fall has retreated since it parted from the American Fall is about 2,500 feet. Allowing five feet per annum as the rate of recession, the parting took place about five hundred years ago. The condition of the American Fall at the time of separation may be inferred in a general way from an examination of the eastern part of the Horseshoe Fall at the present time (Pl. X). From Goat Island to a point about 500 feet westward the water is shallow, corresponding in average depth to that of the American Fall. Beyond that point it is comparatively deep. In the region of deep water the recession of the cataract is rapid, and the portion with shallow water is being left behind. At the

base of that part of the fall where the water is shallow the descending stream does not plunge into the pool, but strikes a talus of rock fragments. These fragments are in part visible, and their existence is elsewhere inferred from the forms given to the spray by the reaction. It seems to me legitimate to infer that the American Fall at the time of its abandonment by the Horseshoe was not so advanced in position as to plunge into standing water, but had already retreated far enough to have acquired a talus above the level of the pool. At the present time the profile of the American Fall where its volume of water is greatest is approximately as shown in fig. 8. The edge of the main river is at S, 220 feet horizontally from the crest of the fall at C, the intervening space being occupied by a gently sloping talus of large limestone blocks, among which the water descends in a labyrinth of cascading torrents (Pl. XI). At the initial stage, when the American Fall was first separated, the position of its crest was probably at some point (I) between its present position and the outer edge of the visible talus. As sketched, I is 160 feet from C, and if the total retreat of the American Fall in five hundred years was 160 feet the average rate of recession was 0.32 foot per annum. Allowance should be made for difference in rate dependent on the gradual encroachment of the protective talus upon the exposed cliff of shale, so that during the earlier part of the period the retreat was more rapid than during the later part. The indication, therefore, is that the present rate of recession is considerably less than 0.32 foot per annum, a result in harmony with that based on the maps and sketches.

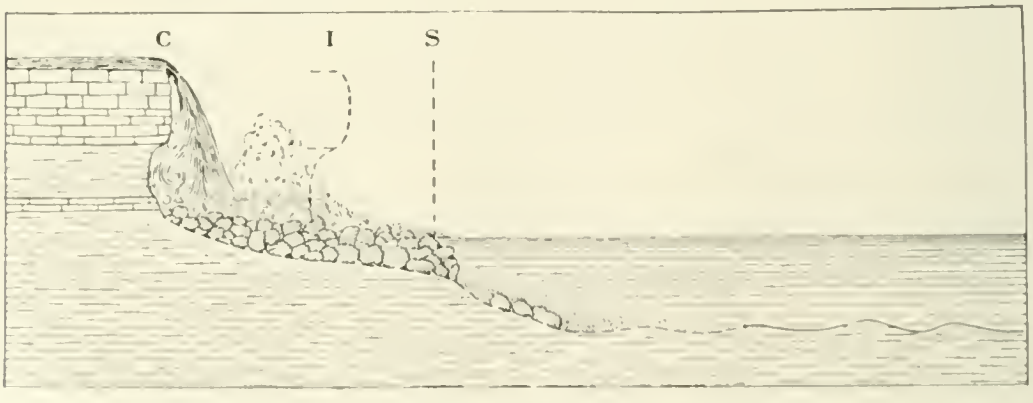


FIG. 8.—Profile and section of American Fall near its middle part. Compare fig. 1, also Pl. XI.

AMERICAN FALL ABOUT 1885.

Shows talus of limestone blocks. Compare with fig. 8 in text, which represents the middle part of the fall.

The assumptions underlying each of the estimates are factors of such importance that neither result can claim a high measure of precision. It appears to be safe to say that the present average rate of recession of the American Fall can not be so great as 0.5 foot per annum, and is probably as small as 0.2 foot per annum, or about one twenty-fifth of the rate of recession of the Horseshoe Fall.

The Map of 1842.

The detection of an important error in the outline of the American Fall as mapped in 1842 tends naturally to bring in question all other results of the survey of that year. Inasmuch as the outline of the Horseshoe Fall as determined in 1842 is one of the most important data used in the computation of the rate of recession, it has been subjected to critical examination and all practicable checks have been applied.

The frame work of the survey includes two stations or "trigonometrical points" on the American shore, three on Goat Island, and three on the Canadian shore. Those on Goat Island were connected, each with the next, by traverse lines, distances being measured by the surveyor's chain and courses observed by the surveyor's compass; so also were the two on the American shore. All other connections were made by compass bearings. From the seven stations thus established the positions of twenty-nine points on the crest lines were determined by intersections of compass bearings. In all the later surveys the bearings were presumably made with the engineer's transit or the plane-table alidade, instruments susceptible of much higher precision than the surveyor's compass; but in view of the shortness of the distances the relative weakness of the surveyor's compass does not seem to me an important factor.

The stations and other points are indicated on the published map, and there is a "table of observations." With the aid of these data positions of points on the crest lines were replotted as a check on the accuracy of the compilation and engraving of the map. This work revealed three errors in the bearings as published, probably to be ascribed to copying or printing and not affecting the map. It indicated also that the points of the crest lines determined by intersection are not all accurately placed on the map, the errors amounting usually to a few feet, but not affecting the computed rate of recession.

Each of the crest-line points was originally located, as a rule, by the intersection of two bearings, but there are four points to which three bearings were taken. In the replotting of these points the check afforded by the third bearing was found to give a satisfactory result. The points which have the advantage of this check are all on the east side of the Horseshoe curve, and include the point at the angle of the Horseshoe in the position where the notch subsequently developed (Z in fig. 4, p. 52). For the remainder, or western part, of the Horseshoe curve there is no similar check, and the three located points of the crest line are so far apart as to give little mutual support. So far as the published data are concerned, these have no higher intrinsic authority than the two points on the American Fall which have been discredited by independent evidence.

The record of the Horseshoe Fall which stands nearest in time to the map of 1842 is Basil Hall's sketch from the Morsyth Hotel (Pl. III, p. 51), the interval being fifteen years. The general form of the crest line is the same in map and sketch, and the tangent based on the sketch is so related to the mapped crest line (fig. 4, p. 52) as to indicate some recession between the dates of the sketch and the map, but the amount of recession is less than would be expected.

The factors bearing on the estimate of the rate of recession are not so related that rigid mathematical methods can be applied to their discussion. The conflict of data and the mutual support of data can be weighed only by nonmathematical methods, and the result of their study is an opinion rather than a decision. The general tenor of the evidence, including the five surveys and the Basil Hall sketch, leaves no question that the annual rate of recession has been about four or five feet. If full authority be ascribed to the map of 1842, the estimated annual rate of recession is 5.3 feet. If full authority be ascribed to the tangent line based on the sketch of 1827, the estimated rate is about one foot less. It is my opinion that the map affords the better record. Giving to it the greater weight and to the tangent a smaller weight, I think the best practicable estimate of the rate is between 5.3 and 4.2 feet, but nearer to the former; and I select five feet partly because a statement in even feet avoids the implication of high precision which

might be suggested by a decimal. As an estimate of the average rate of recession during the period of definite observation, I think this can not be in error more than one foot.

Summary and Conclusion.

The data for computing the rate of recession of Niagara Falls include surveys of the crest line made in 1842, 1875, 1886, 1890, and 1905, and camera-lucida sketches made in 1827. During the period covered by these data the local conditions affecting the rate of recession have not differed to an important extent from the natural conditions. The present and prospective diversions of water for economic uses interfere with the course of nature and may be expected to modify the rate of recession. The natural rate of recession of the Horseshoe Fall is desired by geologists in connection with estimates of the age of the river. The geologic bearing of a rate modified by human agency is less direct. The rate of recession of the American Fall is of interest to geologists because somewhat representative of the river's activity in gorge making when the volume of water was much less.

The rate of recession of the Horseshoe Fall, or the rate of lengthening of the Niagara gorge, during the sixty-three years from 1842 to 1905 is found to be five feet per annum, with an uncertainty of one foot. For the thirty-three years from 1842 to 1875 the rate was apparently slower than for the thirty years from 1875 to 1905. The rate of recession of the American Fall during the seventy-eight years from 1827 to 1905 was less than three inches per annum.

The time consumed in the recession of the falls from the escarpment at Lewiston to their present position, or the age of the river, is not here estimated. It can not properly be computed without taking account of all conditions, local and temporary, affecting the rate of recession, and some of those conditions have varied greatly from point to point and from time to time.

REPORT OF SURVEY OF CREST LINE OF NIAGARA FALLS

By W. Carvel Hall.

In obedience to instructions from Mr. H. M. Wilson, geographer of the United States Geological Survey, issued in consequence of a plan of co-operation with Mr. Henry A. Van Alstyne, State engineer of New York, a survey of the crest line of Niagara Falls was made by me in June, 1905. The determination of the present crest line of the falls was desired in order that, by comparison with maps of earlier dates, the changes could be determined and the rate of recession computed.

Surveys of the falls of which we have record have been made as follows: In 1842, under the direction of Prof. James Hall, State geologist of New York;[a] in 1875, by the United States Lake Survey, published in the form of a chart on the scale of 1:2,500;[b] in 1886, by Prof. R. S. Woodward, then chief geographer of the United States Geological Survey;[c] and in 1890, by Mr. A. S. Kibbe, assistant engineer, under the direction of Mr. John Bogart, State engineer of New York.[d] A survey was also made in 1904 by the Electrical Development Company and Prof. J. W. Spencer, but the map is not yet published.

The great majority of the monuments recovered or established by Mr. Kibbe in his survey of 1890 were found to be in good state of preservation, but a few, one unfortunately an important one, have disappeared. Appended hereto are tables giving descriptions of the various monuments recovered or used, together with their coordinates and the distances between them. In addition to these, there were used in the work temporary stations at Prospect Point, Hennepin View, Stedman Bluff, Rock of Ages, center of south chord of the steel arch bridge, and the cupola of Table Rock House.

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a See Nat. Hist. of New York, pt. 4, Geology, 1843, pp. 402–404.

b Listed by the Lake Survey as Chart No. 48.

c Results published in Seventh Ann. Rept. Comrs. of State Reservation at Niagara, Albany, 1891.

d Idem.

In the survey of 1842 the relations of a few points were fixt by traversing with compass and chain, and the remainder of the work was done by compass, the positions of points on the crest being determined by intersection. In the surveys of 1875, 1886, and 1890 directions were observed by transit instead of compass. In the 1904 work an ingenious method was used, suggested, it is thought, by Mr. Goodwin, of the Electrical Development Company. He carefully measured the elevation of the crest of the falls and also of certain triangulation points on the Canadian bluff. Then, observing at the same instant for direction and for the amount of the "dip-angle," he computed the distance from point of observation to the crest at various places.

Any of these methods seems quite suitable for the determination of the crest at well-marked points, but the upper curve of the Horseshoe Falls has no well-marked points for observation, besides being masked by spray, and the methods adopted require considerable computation and use mainly descriptive matter for identifying even the most important features. As stated by Professor Woodward in his report already referred to —

> The points on the crests of the Falls determined by the 1886 survey varied considerably in respect to clearness of definition and ease and precision of fixture. Some of them were well defined exposures of bare rock: some were less well-defined portions of rock seen through the curved sheet of falling water; some were indentations in such sheets, well defined from any point of view but presenting different aspects from different points of view; and some were ephemeral sprays whose identification from different points of view was a matter of difficulty. * * * the probable error on the crest line does not on the average exceed ±1.5 feet. A much greater probable error must be assigned, however, to the upper part of the Horseshoe Falls.

Mr. Kibbe in his 1890 report states that "for favorable locations on the crest of the falls the probable error is ±1.0 foot, while along the deep-water portion of the Horseshoe Falls it may be somewhat greater."

In view of these facts, a different method was adopted in making the present survey, namely: T. P. No. 1 (at Prospect Point) and "Terrapin" (at Terrapin rocks) were accepted from Mr. Kibbe's survey as initial points, and were plotted to a scale of 1 inch = 200 feet on a plane-table sheet. From these as a base all existing triangulation points were relocated, and with some newly

selected points formed the basis of the survey. Along the American Falls and at the ends of the Horseshoe Falls, by means of photographs and careful descriptions, numerous features were recognized, intersected, and plotted, and the details of the map were continuously compared with the corresponding natural features and their positions checked. Thus any discrepancy between earlier surveys and the present work were at once seen and examined and were thoroughly tested and proved before the work was accepted, the majority of locations being determined from six to eight stations. For the upper portion of the Horseshoe Falls a 30-inch searchlight of very high candlepower, partially masked, was used to mark on the crest of the falls successive small brilliant spots of light, which were simultaneously located by four transits and which it is believed should result in an accurate demarcation of that part of the crest.

An anomalous condition of affairs appears to be disclosed by the survey, similar to that noted in earlier work, viz, that certain points on the crest line have advanced instead of receded. This has heretofore been explained as due to discrepancies in the field work or inaccuracies in the delineation of the crest line between determined points. Doubtless these explanations hold good in all the surveys, past as well as present, but there is one cause of advancement and ultimate recession which does not appear to have been commented on, and which, after close questioning of numerous old residents and careful examination of the situation, I think is a very active element. It might here be emphasized that by the plane-table method used any discrepancy occuring was at once noticed and the new position most carefully checked.

In addition to the erosion caused by the spray and the chemical action of the water on the underlying shales, there is a well-marked change in the crest line, due to the forcing off of large blocks of rock from the crest itself.

Approximately twenty feet below the upper level there is a water-bearing seam in the limestone, particularly well marked at Goat Island and above the Ontario Power Company's new power house. I am informed that in the winter immense icicles form from this seam at various points where it is not noticeable in summer, owing to the quick evaporation. At about this same elevation

there are at present on the American Falls four secondary cascades, or, as termed by the late Thomas V. Welch, Superintendent of the State Reservation, "bustles." In my judgment these can only have been caused by the slipping off of a mass of rock from the crest, sliding to some extent on the water-bearing seam and gradually pressed out by the force of the water and ice in slowly widening cracks upstream till, overbalancing, they fall, leaving the "bustles." The present survey, I believe, has caught some of these masses as they are being forced out.

This theory was discust with a number of the best-informed inhabitants, and while they agreed that large blocks did occasionally fall from the crest, instancing several examples, they claimed that in each case the fall was a sudden one, unaccompanied by any previous pushing forward of the mass. This forward motion, however, must be a very slow one, and would not be noticed, while the final fall of the rock would be assumed to be the beginning and end of the action.

The accompanying plan of the survey (Pl. II, p. 47) shows the existing crest line by a solid line broken only where the flow of water is interrupted by overhanging rocks, and shows the earlier surveys by means of broken lines. Only those triangulation points which are permanently marked are indicated. The shore lines and the various permanent buildings are a compilation of all the records.

In the last few years the brink of the falls has been curtailed on the Canadian side by a wall 495 feet long, completely shutting off the water for that distance, and thereby reducing the length of the Horseshoe Falls by about one-sixth. In recent years five power companies have spent large sums of money to divert a portion of the water now flowing over the falls to their power houses, the total power at present chartered being about one-fifth of all available.

I desire to acknowledge my indebtedness for material assistance rendered in the work to Mr. Edward H. Perry, Superintendent of the State Reservation at Niagara; to Mr. James Wilson, Superintendent of the Queen Victoria Niagara Falls Park; to Mr. B. F. R. Paine, General Manager of the Ontario Power Company, and to Mr. J. W. Kellogg, Manager of the marine sales department of the General Electric Company.

Tables.

The first of the following tables includes artificial monuments and other permanent reference points connected with the triangulations of the surveys. The designation, description, and location of each are given, together with its coordinates as referred to Topographic Point No. 1 of the survey of 1842. The coordinates, with the exception of Semaphore, are taken from Mr. Kibbe's table in the Seventh Annual Report of the Commissioners of the State Reservation at Niagara, pages 105 to 107.

SURVEY OF CREST LINE OF NIAGARA FALLS.

List of permanent reference points.

Designation.	Description.	Coordinates.	
		Feet.	*Feet.*
T. P. No. 1.....	1842, 1890, 1905. Stone monument 5 inches square on Prospect Point 1 inch below sod, 138 feet from southwest corner stone house at head of incline, 145 feet from northwest corner of same, and 15 feet from iron lamp-post.	0.0	0.0
M.....	1890, 1905. Stone monument 5 inches square, 1 foot below surface, with 6-inch terra-cotta tile over it, set on bluff in extreme edge of gravel walk at Porters Bluff, just east of path to the Terrapin Rocks.	S. 1,929.1	W. 1,206.5
T. P. No. 6.....	1842, 1890, 1905. Stone monument 5 inches square, in path following top of bluff along southern shore of Goat Island. This monument projects about 7 inches and is marked "6" on side.	S. 2,370.7	W. 990.4
Terrapin.....	1886, 1890, 1905. Brass bolt 1 inch in diameter set in prominent square rock about 4 feet high, word "Terrapin" cut in top of rock at end of wooden walk to platform where Terrapin Tower formerly stood. Believed to coincide very nearly with point used in 1875.	S. 2,044.2	W. 1,465.5
Loretto.....	1886, 1890, 1905. Cross surmounting cupola of Loretto Convent, also brass screw one-half inch in diameter in the deck of cupola directly under center of cross.	S. 3,671.4	W. 3,623.4
N.....	1890, 1905. Brass bolt 1 inch in diameter near superintendent's office, Canadian side, set in the rock 1 foot under surface of lawn and surrounded by 4-inch terra-cotta tile, 34.9 feet from southwest corner main building and 18.3 feet from southeast corner same.	N. 1,021.9	W. 1,462.1
B.....	1890, 1905. Brass bolt 1 inch in diameter set in rock between pipe railing and brink, in Canadian Reservation, 30.2 feet from northeast corner of railing at "Ramblers Rest."	N. 788.5	W. 1,451.8
C.....	1890, 1905. Stone monument 6 inches square between pipe railing and brink, in Canadian Reservation, 25.4 feet northerly from pipe of drinking fountain south of "Ramblers Rest."	N. 193.9	W. 1,751.6
D.....	1890, 1905. Stone monument 6 inches square, between pipe railing and brink, in Canadian Reservation, a little south of "Inspiration Point."	S. 458.2	W. 2,090.4
I.....	1890, 1905. Stone monument 6 inches square, marked "I" on side, set in prominent projecting point at top of bluff on Canadian side about 317 feet southeasterly from south gable of Ontario power house, now in course of construction (June, 1905).	S. 1,602.5	W. 2,773.2
K.....	1890. Stone monument like last, about 490 feet southwardly along bluff.	S. 1,934.7	W. 2,996.2
L.....	1890. Stone monument like last, about 490 feet southwardly along bluff.	S. 2,338.0	W. 3,261.3
Semaphore.....	Center of 8-inch iron pipe sunk several feet in the ground on west bank railway cut about opposite Clarke Springs.	S. 2,496.6	W. 3,507.2
O.....	1890. Stone monument 6 inches square set into slope at Stedmans Bluff; covered in 1900 by dry stone wall; references as on line between T. P. No. 1 and a nail in root of large leaning oak tree 21.41 feet southwest and 49.7 feet from nail in root of basswood tree.	S. 989.1	W. 597.1

Tables.

Distances between permanent reference points.

[Based on table of A. S. Kibbe in Seventh Ann. Rept. Comrs. State Res. Niagara, p. 112.]

	T. P. No. 1.	M.	T. P. No. 6.	Terrapin.	Loretto.	N.	B.	C.	D.	I.	K.	L.	O.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
T. P. No. 1	0.0		2,569.0	2,515.3		1,783.8	1,652.1	1,762.3	2,140.0	3,202.9	3,566.6		1,155.3
M		0.0	491.5	283.4									
T. P. No. 6	2,569.0	491.5	0.0	576.3	2,936.4					1,941.1	2,052.3		
Terrapin	2,515.3	283.4	576.3	0.0	2,702.6				1,704.7	1,380.3	1,534.6	1,839.4	
Loretto			2,936.4	2,702.6	0.0					2,236.5		1,376.6	
N	1,783.8					0.0			1,607.9				
B	1,652.1						0.0						
C	1,762.3							0.0	734.8				1,652.9
D	2,140.0			1,704.7		1,607.9		734.8	0.0				1,584.9
I	3,202.9		1,941.1	1,380.3	2,236.5					0.0			
K	3,566.6		2,052.3	1,534.6							0.0		
L				1,839.4	1,376.6							0.0	
O	1,155.3							1,652.9	1,584.9				0.0